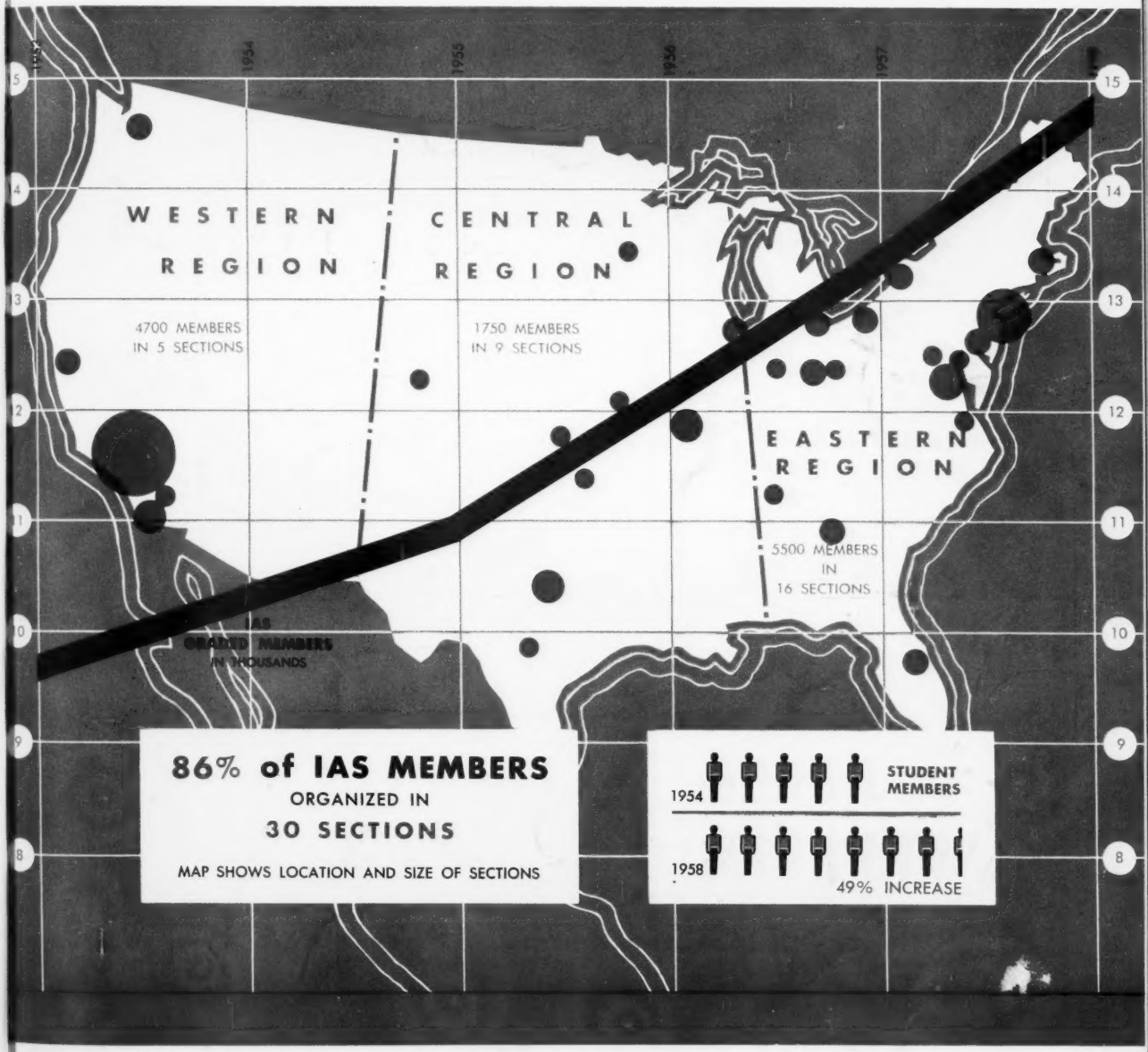
EPARTMENT OF TECHNOLOGY
LO AND ERIE COUNTY PUBLIC LIBRARY

AERO/SPACE ENGINEERING

REVIEW OF CURRENT AND FUTURE TRENDS IN AIRCRAFT • MISSILES • ROCKETS • SATELLITES • SPACECRAFT



In this issue

THE 5-YEAR LOOK

IAS Progress Report—Editorial . . . . . p. 22

JANUARY | 1959

XUM

POWER FOR MISSILE & AIRCRAFT HYDRAULIC SYSTEMS

Eastern

HIGH SPEED GEAR PUMPS

SHOWN ACTUAL SIZE

Eastern Aviation Hydraulic Pumps set new standards for performance, yet ar the smallest, most lightweight ever made.

By meeting customer requirements and government specifications with precise detail, Eastern Pumps give reliable long-term service.

Hundreds of models, close-coupled to electric motors with speeds to 24,000 RPM, can be furnished for your special systems. You gain the advantage of economical mass-produced components custom-engineered into whatever configuration is needed. Performance is from .015 to 1.5 GPM, 0 to 3000 PSIG, with theoretical displacements from .0021 to .0419 cubic inches per revolution. A variety of bearing combinations handle different types of fluid and operating pressures.

Missile and aircraft system engineers have discovered Eastern Pumps do the sam job as units that use greater space and weigh far more. Applications have included circulating coolant in bomber guidance system, providing hydraulic power for ground control of jet, charging accumulator in an in-flight refueling system, furnishing an APU system with power to a missile, and countless others

For your next project, contact Eastern for creative engineering help that really hel

Write for NEW Aviation Bulletin 350 describing the above units and larger-capacity pumps.

Eastern AVIATION PRODUCTS

EASTERN INDUSTRIES, INCORPORATED

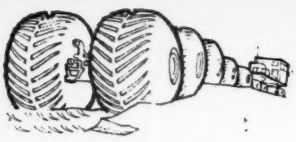
100 Skiff Street • Hamden 14, Conn. West Coast Office: 1608 Centinela Avenue • Inglewood 3, Califor

XUM

60 379 B B 13

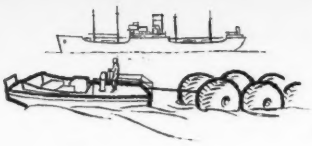
Does your weapon system need fuel "on the double"?

Here—from Goodyear—are ingenious new rubberized containers that offer double dividends: lightweight liquid storage plus unmatched all-weather mobility.



NEED FUEL THAT ROLLS WITH YOU?

These big Rolli-Tankers hold 500 gallons each, can be towed in long "fuel trains" over roughest terrain. Tire-like containers roll so easily a man can pull one.

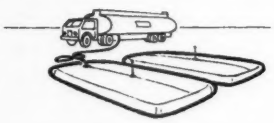


—OR FLOATS WITH YOU?

Filled with fuel, Rolli-Tankers have natural buoyancy—ride through water, roll right up the beach! Eliminates long-line hoses and pumping.

—OR COMES BY AIR?

Delivered by air, Rolli-Tankers can be attached to waiting trucks *—and rolling*—in matter of minutes. Fully loaded tankers survive free falls of 15 feet.



HOW ABOUT A PORTABLE FUEL FARM?

Called "Pillow Tanks," these tough, rubberized fabric containers can be set up, filled and pumping in 45 minutes. Great where temporary or emergency storage of bulk liquids is needed.

LOOK! FLOATING FUEL STATION

"Pillow Tanks" *in the water* serve as "fuel islands"—eliminate stringing of long-line hoses or pumping from remote point. Tanks available in sizes up to 50,000 gallons.

WANT TO SAVE FUEL SPACE?

Goodyear has pioneered the development of spacesaving fuel cells and tanks for aircraft, boats, vehicles, missiles. This experience can best answer *your* fuel storage problem.

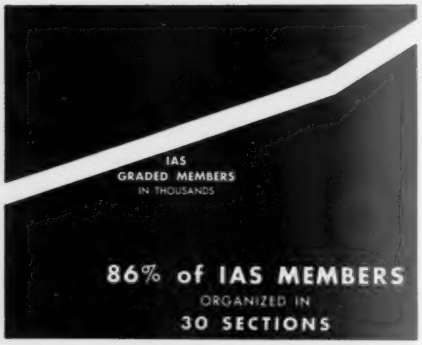
FOR COMPLETE INFORMATION on these and other new developments in fuel storage and transport, write Goodyear, Aviation Products Division, Akron 16, Ohio, or Los Angeles 54, California.

AVIATION PRODUCTS BY

GOODYEAR

Rolli-Tanker—T. M. The Goodyear Tire & Rubber Company, Akron, Ohio

XUM



On our cover

The cover and 5-page Editorial (pp. 22–26) in this issue constitute a condensed 5-Year Progress Report to IAS Members on Institute affairs. These facts and figures have been taken from a much more voluminous report prepared by the Staff for the Council and its Long-Range Planning Committee. The full report has also been distributed to every IAS Section Chairman and is, therefore, available to any member who wishes to see, in greater detail, where we have been and where we are going.

PUBLICATION STAFF

Publisher: Welman A. Shrader

Editor: Allan Bernhardt

Managing Editor: Rita J. Turino

Reviews Editor: Irene W. Bogolubsky

Book Reviews Editor: John J. Glennon

Editorial Assistant: Helen S. Goldman

Technical Advisers:
W. R. Sears, Robert R. Dexter, S. Paul Johnston

Business Staff:
Advertising Manager: Joseph P. Ryan
Western Representative: John Ball, Jr.
Business & Production Manager: Hugh C. Judge
Assistant Production Mgr. D. C. Lombardi

AERO/SPACE ENGINEERING

. . . formerly *Aeronautical Engineering Review*, is published monthly by the Institute of the Aeronautical Sciences, Inc., at 20th and Northampton Streets, Easton, Pa. Headquarters and Editorial Offices: 2 East 64th Street, New York 21, N.Y. (TEmpleton 8-3800). Western Office: 7660 Beverly Blvd., Los Angeles 36, Calif.

Subscription rates: United States and possessions, 1 year, $5.00; single copies, $0.50. Foreign countries including Canada (American currency rates), 1 year, $6.00; single copies, $0.50.

Second-class mail privileges authorized at Easton, Pa. Acceptance for mailing at a special rate of postage as provided for in the Act of August 24, 1912.

Notices of change of address should be sent to the Institute of the Aeronautical Sciences, Inc., 2 East 64th Street, New York 21, N.Y., at least 30 days prior to actual change of address.

© Copyright 1958 by the Institute of the Aeronautical Sciences, Inc.

Statements and opinions expressed in *Aero/Space Engineering* are to be understood as individual expressions and not those of the Institute.

EDITORIAL ADVISORY COMMITTEES

Space Technology

Rear Adm. Rawson Bennett, USN
Major Gen. Otis O. Benson, Jr., USAF(MC)
Milton Clauser
Major Gen. Marvin Demler, USAF
Krafft A. Ehricke
Brig. Gen. H. F. Gregory, USAF
Major Gen. J. B. Medaris, USA
Capt. Alfred B. Metsger, USN
Courtland Perkins
E. R. Piore
H. Guyford Stever
Hubertus Strughold, M.D.
Herbert York

Specialties

Robert J. Benford, M.D.
Melvin N. Gough
Jerome Lederer

Design, Structures, & Materials

A. Francis Arcier
Wellwood E. Beall
William B. Bergen
Fred N. Dickerman
Robert L. Hall
Edward H. Heinemann
Harold D. Hoekstra
C. L. Johnson
Alexander Kartveli
Kendall Perkins
Richard L. Schleicher
Edgar Schmued
Igor I. Sikorsky
Ernest G. Stout
Kirby F. Thornton
Walter Tydon

Electronics

K. C. Black
Bruce G. Eaton, Jr.
Richard B. Hubbard
David S. Little
Frank Mansur
John Margosian
P. C. Sandretto

Flight Propulsion

George W. Brady
Dimitrius Gerdan
Leonard S. Hobbs
R. P. Kroon
Everard M. Lester
W. G. Lundquist
Abe Silverstein
Philip B. Taylor
E. S. Thompson
Raymond W. Young

Instruments

Preston R. Bassett
Victor E. Carbonara
Charles H. Colvin
Frank R. Cook
Richard M. Mock
Walter H. Skidmore
R. C. Sylvander

Air Transport & Operations

Charles Froesch
J. A. Herlihy
John C. Leslie
William Littlewood
R. W. Rummel
R. Dixon Speas

formerly
AERONAUTICAL ENGINEERING REVIEW

AERO/SPACE ENGINEERING

VOLUME 18 / NUMBER 1 **January 1959**

Featured in this issue

A New Feature **5** Letters to the Editor
All readers are invited to voice their opinions—technical or otherwise.

IAS Progress Report **22** The 5-Year Look (Editorial)
A review of the recent past as a study for the future.

J. T. Guerin, J. G. Carroll, R. O. Bolt, and J. A. Bert
California Research Corporation
27 Nuclear Radiation and the Thermal Stability of Jet Fuels
Evaluation of a vital property of fuels is emphasized in this exclusive report on recent test work.

E. William Beans
Pennsylvania State University
32 Comparing Aircraft Engines by Mission Requirement and Aircraft Performance
Basis of comparison is a parameter termed "engine factor"—ratio of engine thrust to weight of propulsion system and payload.

Lewis Larmore
Lockheed Aircraft Corporation
37 Celestial Observations for Space Navigation
The author discusses three extensions of earth-bound celestial navigation systems and urges additional investigations.

A. W. Lane, M. S. Klemes, and E. L. Zeigler
Sperry Gyroscope Company
43 Achieving Extremely Accurate Nonfloated Gyros
A new suspension has caused gyro drift error to be at least ten times smaller than conventionally.

Fred B. Stencel
Stencel Aero Engineering Corporation
47 Extending Capabilities of Escape and Aerial Delivery Systems
By adding a self-contained power source to the parachute canopy, its deployment process has been made greatly independent of airflow conditions.

Seymour J. Deitchman
Cornell Aeronautical Laboratory, Inc.
53 The Occurrence and Avoidance of Midair Collisions
His analysis leads this author to conclude that the greatest danger results from encounters between pairs of aircraft wherein at least one is in VFR flight.

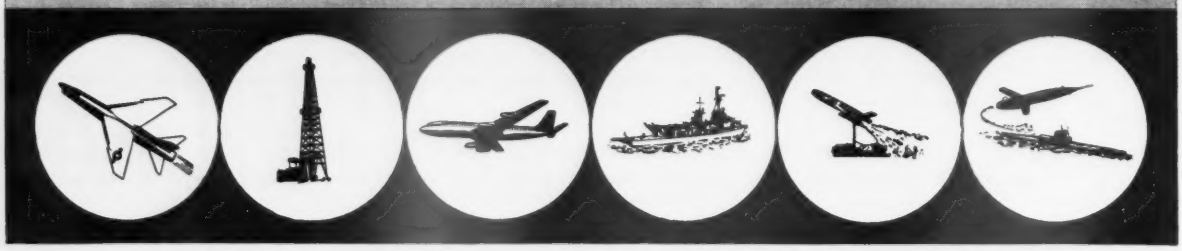
A Special Service **64** List of Periodicals
Information on publications maintained in the IAS Library and reviewed in the Aeronautical Reviews and International Aeronautical Abstracts sections of this magazine.

Departments

9 IAS News Notes
13 IAS News
21 Dateline World
36 Fairchild Fund Papers
42 Special Publications
63 Reviews
91 International Abstracts
115 Books
121 Personnel Opportunities
122 Index to Advertisers
123 New Products and Literature

SARGENT

SERVO-SYSTEMS OF FORCE CONTROL



With 38 years acceptance Sargent builds precision linear and rotary hydraulic, pneumatic, mechanical and electronic systems of force control to meet successfully the increasingly high requirements of marine, aircraft, missile, petroleum and industrial use. From original idea to finished product – SARGENT.

SARGENT FACILITIES	Manufacturing including –
Research	Machining & Grinding
Design	Heat Treating, all types
Development	Plating, all types
Testing	Inspection
Qualifying	Assembly

SARGENT BUILDS	
Servo-Systems	Hydraulic Pumps
Hydraulic Systems	Hydraulic Motors
Integrated Packages	Pneumatic Cylinders
Hydraulic Actuators	Pneumatic Valves
Hydraulic Valves	Ball Screw Actuators
	Gear Actuators
	Gear Accessory Boxes
	Electronic Systems

Standard of Excellence — *Since 1920*

Sargent — QUALITY BUILDS GOOD WILL

ENGINEERING CORPORATION

MAIN OFFICE & PLANT, 2533 E. FIFTY-SIXTH ST.
HUNTINGTON PARK, CALIF.

"GOOD WILL" is the disposition of the pleased customer to return to the place where he has been well treated.
– U.S. Supreme Court

LETTERS to the Editor

■ I am increasingly impressed with the constantly growing complexity of modern aeronautical devices of all kinds, and the inevitable results in decreased reliability, increased costs, and sometimes deterioration of safety. I appreciate that such complexity is the inevitable result of developments in the state of the art and the ever-growing desire and ability to accomplish more and more refined objectives. However, the deterioration in reliability is a very regrettable by-product. Anything that can be done to improve the situation would seem helpful.

As one facet of the problem, it is my impression that with the shortage of engineers and scientists, of which we hear repeatedly, and the pressure of waiting projects, there is a very natural tendency to move college graduates, with their one, two, or three degrees, straight from the cloistered halls of learning into the productive patterns of research development or design. I am aware that the apprenticeship system has long departed from these shores, but I am also convinced that there is no substitute for practical experience which includes rolling up your sleeves and getting your hands dirty and developing a proper appreciation of the practical performance of making things simple, rugged, dependable, and safe. I am afraid that a substantial amount of our deterioration in reliability is due to the impractical attitudes and lack of practical experience of our scientists and engineers, despite the fact that we attribute it to inherent complexity.

I would like to invite a broad discussion of the basic elements of our requirements for reliability in this age of complexity. **William Littlewood, HFIAS, Vice-President—Equipment Research, American Airlines, Inc.**

✦ ✦ ✦

■ Will you please forward the following comments to Louis P. Stannard, author of "Spares for Weapons Systems".

"We wish to commend you on your article recently published in the August edition of AERO/SPACE ENGINEERING. Your article was found to be very timely and interesting. We are disseminating your article throughout the Maintenance Division in the Bureau of Aeronautics to accent more vividly the problems in this area. Spares for weapons systems is considered a vital link in the chain of support.

Again we wish to commend you on your article and say that we are pleased to see that you are so keenly aware of the problem." **R. R. Ayres, Jr., Lt. Col., USMC. Head, Weapon Systems Section, Maintenance Div. By direction of the Chief of Bureau.**

■ Among the reviews published by A/SE there often occur reviews of Russian articles. Someone who knows the English language has therefore read and reviewed the articles, and it would be very useful if the name of the reviewer or the source of the review could be included. Also, it would help immensely if the location and availability of translations could be given.

The matter of keeping up with the foreign literature, particularly the Russian, is a vexing one for the writer, and probably for other specialists as well. Have you considered some sort of service, beyond the publication of these reviews, to help in the location of translations.

I find the new format of A/SE (compared to AER of a year ago) quite good, and the reviews are most useful to me. I consider my dues well spent for this publication alone. **Myron Tribus, MIAS, Department of Engineering, University of California.**

The Institute is seeking solutions to problems in collecting and publishing data on Soviet work. John Glennon, Chief IAS Librarian, returned only recently from a 6-week visit to the U.S.S.R. Watch A/SE *for the full report of his findings and current status of the problem.*—ED.

✦ ✦ ✦

■ With its recent change in name, AERO/SPACE ENGINEERING is moving forward with the times. The problems of space navigation are challenging over all others. However, there are two major areas right here in the troposphere that need our best attention in order that the transport of goods and people, whether through the earth's atmosphere or beyond it, may continue to grow on a sound foundation. These are Safety and Economy.

Do our members feel the need for more emphasis on these two? Can these be dealt with in a more scientific and fundamental manner?

Here are just a few of the many problems bearing on safety and economy that need increased attention and technical discussion:

Starting and Stopping: Accelerating and decelerating a big transport continues to require greater runway lengths. Our current acceleration and deceleration values are around 0.25g. Passengers could probably tolerate twice this value without discomfort. Progress here would aid both safety and economy.

Fatigue: Tired metal is a serious problem in engines, propellers, hellicopters, and airplanes. Can we develop a test that will tell us figuratively when one more cycle will start a crack? Can we align the crystals, if that be the answer, to keep the crack from starting?

Noise: In science and engineering we move mountains and split atoms However, when it comes to fundamental improvements in noise reduction of jet engines, for example, we throw up our collective hands. The best scientific minds seem to limit their unlimited horizons to only a few decibels. A new approach is needed.

Propellers: The problem of getting engine power changed into reaction becomes more difficult as the power goes up. Jets and by-pass or ducted fan engines help in certain cases. Propeller efficiencies are good, but new thinking is needed to eliminate windmilling drag and "runaway propellers."

Helicopter Vibration: Helicopters are known as vibration machines, and not without reason. Do we need new concepts of balancing, relative positioning, and control?

Anticollision: This is a very serious problem—and it is worsening. Work is under way, but it is limited. It should be possible for the pilot to "see" and avoid other aircraft—in day, night, or cloud conditions—without gadgets in the other craft. Have we exhausted all of the possibilities of radar, light, infrared, sound, magnetism, and other phenomena?

Let's keep our eye on space, but not trip our foot on atmosphere. **Harold D. Hoekstra, FIAS, Arlington, Va.**

✦ ✦ ✦

■ You may be interested to know that our Science-Technology Information Service Center publishes monthly for internal circulation a little pamphlet reporting on important and interesting articles from technical journals. In the August issue were listed 26 articles from 23 journals. Of these, three were listed as having been published by AERO/SPACE ENGINEERING. Only one other journal had more than one article listed.

The particular articles selected from A/SE were "Small Power Plants for Use in Space" (from the July issue), "How to Evaluate Engineers" (from the July issue), and "Direct Cycle Nuclear Turbojet Power Plants" (from the August issue). I particularly like the article by Ryder on how to evaluate engineers as it offered a fresh and practical approach to this perennially troublesome problem. **Fred N. Dickerman, FIAS, Assistant Chief Engineer, Georgia Div., Lockheed Aircraft Corp.**

The Editors welcome letters from readers, although none can be acknowledged. All must be signed, but identities will be withheld on request.

XUM

HOW SMALL

CAN PRECISION COMPONENTS BE?

Synchros and associated components now can be small enough and light enough for use in many crucial assignments where size and weight must be minimal. Ketay has led the way in miniaturization without sacrifice of performance and environmental resistance.

Ketay's size 8 components meet and surpass current MIL design objectives. They are available in production quantities to meet strict delivery schedules.

Notable examples of Ketay competence in miniaturization include:

Size 8 synchros—only Ketay offers a complete line including high impedance units. Exclusive construction features—as well as stainless steel housing and materials of matched temperature coefficients—help assure high accuracy over a wide temperature range and resistance to corrosion and deformation.

Size 8 servo amplifiers—only Ketay offers transistorized 0.8 cubic inch units which deliver 2 watts output continuously from —55° to 100° C without a heat sink; 200 to 1000 volt normal gains can be supplied.

Size 8 servo motors—Ketay offers units of outstanding high ratio of stall torque to power input (0.25 oz. in. for 3.4 watt input at 6500 rpm), center-tapped for transistorized applications.

Ketay engineers are regularly working on advanced new components and prototype control systems. Call or write for help in solving your special problems.

Ketay precision components:
SYNCHROS
RESOLVERS
POTENTIOMETERS
SERVO MOTORS
TACHOMETERS
SERVO AMPLIFIERS
GYROMECHANISMS
Catalogues available.

NORDEN DIVISION of United Aircraft Corporation

KETAY DEPARTMENT, Commack, Long Island, N.Y.

For moderate, economical silencing of jet-powered commercial and military aircraft . . .

NEW KOPPERS PORTABLE RUN-UP SILENCER TAKES THE PUNCH OUT OF JET NOISE

Now, airports, air bases and manufacturers of jet engines or airframes can run up jet engines without complaint or creating physical hazards. The Koppers Portable Run-Up Silencer reduces noise by 25 to 30 decibels—lessens the risk of hearing damage to operating personnel, improves community relations and reduces speech interference.

The new portable silencer inhibits the generation of jet engine noise, rather than suppressing it after the noise has reached full intensity. The unit is light in weight and completely portable—no direct attachment to the aircraft or engine is necessary. Look to Koppers with its longest experience in the industry to solve your aviation noise control problems.

Write for Koppers new sound control brochure today. KOPPERS COMPANY, INC., Sound Control Department, 5901 Scott Street, Baltimore 3, Maryland.

Official United States Navy Photographs

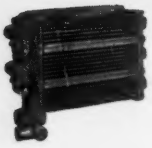
KOPPERS

SOUND CONTROL

Engineered Products Sold with *Service*

XUM

GENERAL MOTORS COOLS POPULAR PIPER COMANCHES!



Harrison aircraft oil coolers—engineered & built to General Motors standards of quality

PIPER SPECIFIES HARRISON OIL COOLERS FOR NEW FOUR-PASSENGER BUSINESS AIRCRAFT

Engine heat gets the "Indian sign" from Harrison in these Piper Comanches! Piping hot in popularity, they cruise cool with lightweight, durable Harrison heat exchangers. Both Comanches shown, the four-cylinder 180 and the six-cylinder 250, are ideal for the modern business executive . . . for the man on the move! Naturally, Piper must demand absolute dependability. That's why Harrison is specified for engine oil cooling on these two featured stars of the Piper business fleet. Piper and manufacturers of every type of modern aircraft, from transcontinental bombers to city-hopping helicopters, rely on Harrison for the finest in cooling equipment. Harrison offers engineering excellence, production skill and never-ending research backed by nearly a half century of experience in the heat-control field. If *you* have a cooling problem, look to Harrison for the answer!

TEMPERATURES MADE TO ORDER

HARRISON

AIRCRAFT, AUTOMOTIVE, MARINE AND INDUSTRIAL HEAT EXCHANGERS

GM GENERAL MOTORS

HARRISON RADIATOR DIVISION, GENERAL MOTORS CORPORATION, LOCKPORT, NEW YORK

IAS News Notes

January 1959

'REPORTS' vs 'PREPRINTS' -- The broadening of IAS activities and increase in the quantity of technical papers presented at national meetings (see editorial) have brought a change in identification of these papers. To permit referencing in literature prepared subsequent to the presentation of these papers, they will be assigned permanent numbers indicating the year of origin and known henceforth as IAS REPORTS. The mechanical process remains the same.

IAS ANNUAL MEETING luncheon speakers will be Herbert F. York, Chief Scientist, ARPA; Major General Donald J. Keirn, USAF, Assistant Deputy Chief of Staff, Development for Nuclear Systems, Dept. of the Air Force; and Carl A. Covington, Executive Secretary, Advisory Panel on Aeronautics, Office of the Asst. Secretary of Defense. They will speak on January 26, 28, and 29, respectively.

TWO ADDITIONAL COMPANIES have joined the list of IAS Corporate Members (published each month on the Journal of the Aero/Space Sciences back cover). The Institute welcomes Chicago Aerial Industries, Inc., Melrose Park, Ill., and Del Mar Engineering Laboratories, Los Angeles.

FOUR TECHNICAL SESSIONS -- Air Breathing Engines - Nuclear Power for Flight - Rocket Propulsion - and Propulsion and Power for Space Flight - have been scheduled for the Institute's Flight Propulsion Meeting (Classified) at the Hotel Carter, Cleveland, Ohio, on March 5 and 6. The Meeting's General Chairman is Dr. Walter T. Olson, Chief of the Propulsion Chemical Division, Lewis Research Center, NASA. More complete advance data on this meeting is scheduled for the next issue of A/S E.

LETTERS BY THE PAGEFUL -- Safety, Economy, Keeping Up with Foreign Literature, and Reliability; these and other subjects are taken up in Aero/-Space Engineering's new feature, "Letters to the Editor". The inaugural of this thought-provoking department is on Page 5 of this issue.

THE INSTITUTE HAS PUBLISHED the third edition of "The Aerospace Industry", a compilation of the plants and facilities in the U. S. engaged in the research, design, or manufacture of airframes and propulsion units for aircraft, missiles, rockets, and outer space vehicles. A list of Government aerospace research and test centers is included. The 36-page report is priced nominally at 50 cents per copy. Inquiries should be addressed to Advertising Department, Aero/Space Engineering, 2 E. 64th Street, New York, New York.

* * * * *

SECTION MEETINGS CALENDAR

Jan. 7 — Chicago: Meeting, Austin Fine Arts Club, 8 p.m. "The NASA Space Technology" by Dr. John S. Victory, Assistant to the Administrator, NASA.

Jan. 8 — Hampton Roads: Classified Meeting, East Area Administration Building, NASA, 8 p.m. "Air Force Research & Development in the Space Age" by Colonel Carlo R. Tosti, USAF.

Jan. 9 — Texas: Joint SAE-IAS Dinner Meeting, Lucas B & B Restaurant, Dallas (Cocktails at 6:30, dinner at 7:30, meeting at 8:30). "Incentives to Bring Out the Best in Engineers" by Adm. L. B. Richardson, USN (Ret.), Sr. Vice President, General Dynamics Corp., and "Professional Aspects of Engineering" by Charles F. Savage, Consulting Engineer, Professional Relations, G.E. Co.

Jan. 13 — Columbus: Dinner Meeting (Dinner at 7 p.m., meeting at 8:15). "Flight Controls for Space Vehicles" by Ron Anderson, Aero-Mechanics Branch, Flight Controls Lab., WADC.

Jan. 13 — San Antonio: Meeting, 6:30 p.m. "Space Exploration" by Maj. W. R. Aiken.

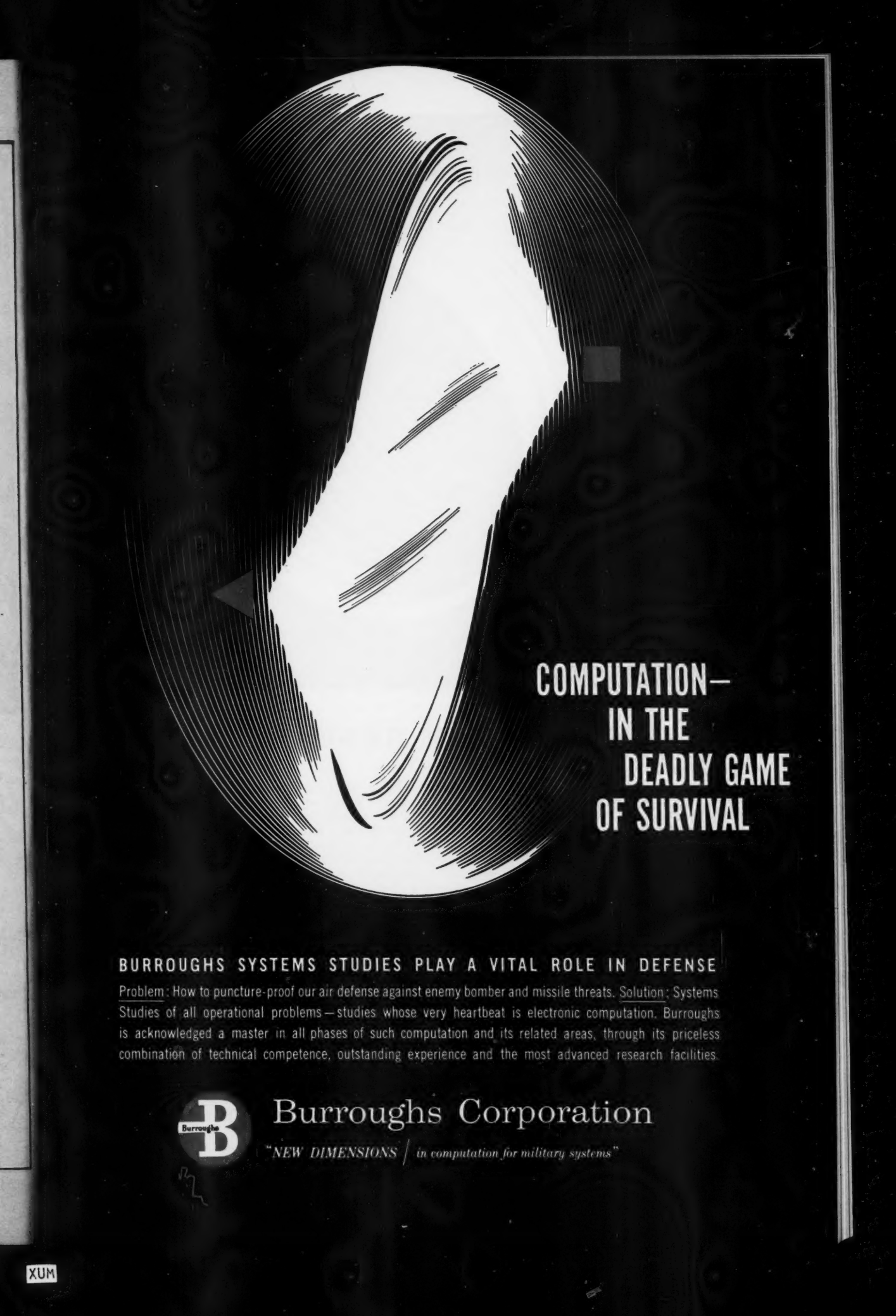
Jan. 14 — Niagara Frontier: Meeting, Cornell Aeronautical Laboratory, Buffalo, 8:30 p.m. "Rocket Boosted Glider as a Space Vehicle" by Dr. Everett T. Welmers.

Jan. 14 — Tulsa: Family Night (Dinner at 6:00, films at 7:15), Borden's Cafeteria (Brook Plaza, 51st & Peoria), Tulsa. Films: "We Saw It Happen" and "Aerodynamics Oddities".

Jan. 22 — San Diego: Joint IAS-Human Engineering Society Meeting, 8 p.m. "Exercise of Air Defense" by Dr. L. F. Carter.

INTERNATIONAL, NATIONAL & JOINT MEETINGS CALENDAR

Jan. 26-29	Twenty-Seventh Annual Meeting, Hotel Astor, New York, Honors Night Dinner, Tuesday, January 27.
Mar. 5-6	Flight Propulsion Meeting (Classified), Cleveland.
Apr. 5-10	1959 Nuclear Congress, Municipal Auditorium, Cleveland.
May 25-27	National Telemetering Conference, Cosmopolitan Hotel, Denver. Sponsored by IAS, ARS, ISA, and AIEE.
June 11-13	1959 Heat Transfer and Fluid Mechanics Institute, University of California, Los Angeles. Cosponsored by IAS.
June 16-19	National Summer Meeting, Los Angeles.
Oct. 5-16	Seventh Anglo-American Aeronautical Conference, New York.
Oct. 29-31	National Midwestern Meeting on "New Frontiers in Aviation" Wichita, Kansas



BURROUGHS SYSTEMS STUDIES PLAY A VITAL ROLE IN DEFENSE

Problem: How to puncture-proof our air defense against enemy bomber and missile threats. Solution: Systems Studies of all operational problems—studies whose very heartbeat is electronic computation. Burroughs is acknowledged a master in all phases of such computation and its related areas, through its priceless combination of technical competence, outstanding experience and the most advanced research facilities.

Burroughs Corporation

"NEW DIMENSIONS / in computation for military systems"

XUM

Microwave delay line for use in airborne equipment.

MICROWAVE RESEARCH

The expanding role of electronic equipment in modern military operations has given high priority to microwave research. No field today offers greater challenge to the scientist and engineer.

In support of current electronic countermeasures programs and in anticipation of future systems requirements, Ramo-Wooldridge Division is engaged in microwave research to develop new techniques and to refine conventional components.

Research is under way at Ramo-Wooldridge for new methods and new designs to reduce substantially the over-all size, weight and complexity of electronic equipment for both airborne and ground-based uses.

For example, the low-loss delay line in the photograph above was designed, developed and manufactured by Ramo-Wooldridge for use in airborne equipment. Packaged for use in the system for which it was designed, this miniature ceramic unit weighs less than two pounds. It replaces a component which weighed more than twenty pounds and occupied more than five times as much volume.

Special opportunities exist for those with qualified experience in microwave research—in technique evaluation, component development, and design of such systems equipment—at Ramo-Wooldridge.

Engineers and scientists are invited to explore openings at Ramo-Wooldridge in:

- Electronic Reconnaissance and Countermeasure Systems
- Infrared Systems
- Analog and Digital Computers
- Air Navigation and Traffic Control
- Antisubmarine Warfare
- Electronic Language Translation
- Information Processing Systems
- Advanced Radio and Wireline Communications
- Missile Electronics Systems

RAMO-WOOLDRIDGE

P.O. BOX 90534 AIRPORT STATION • LOS ANGELES 45, CALIFORNIA

a division of ***Thompson Ramo Wooldridge Inc.***

IAS News

. . . a record of people and events of interest to Institute Members

William Littlewood Elected IAS President

American Airlines V-P, New Vice-Presidents, and Treasurer, to Take Office at Honors Night Dinner

WILLIAM LITTLEWOOD, Vice-President—Equipment Research for American Airlines and IAS American Honorary Fellow for 1957, has been elected President of the Institute for 1959. A former Vice-President of the IAS (in 1950), he succeeds Edward C. Wells, Vice-President – General Manager, Systems Management Office, Boeing Airplane Co.

Mr. Littlewood, recipient of many honors during his more than 30 years in commercial aviation and credited with numerous important contributions in the development of commercial air transports, served on the IAS Council during the last year. He and the other new officers will take office at the IAS Honors Night Dinner on January 27.

Newly Elected Officers

New Vice-Presidents are:

Clifford C. Furnas, Chancellor of the University of Buffalo. He is an IAS Fellow.

Clarence L. Johnson, Vice-President—Research and Development, Lockheed Aircraft Corp. Mr. Johnson also is a Fellow of the Institute.

I. Nevin Palley, Vice-President—Engineering, Temco Aircraft Corp., an IAS Associate Fellow.

Raymond C. Sebold, Vice-President—Engineering, Convair, A Division of General Dynamics Corp., an IAS Fellow.

Elected 1959 Treasurer was Jerome Lederer, Director, Flight Safety Foundation. Mr. Lederer also is an IAS Fellow.

The Council re-elected S. Paul Johnston as Director of the Institute. Mr. Johnston will begin his fourteenth year with the IAS in May. Also re-elected were Secretary Robert R. Dexter and Controller Joseph J. Maitan.

President-Elect Winner of Many Honors

President-elect Littlewood's latest honor in the field to which he has devoted half a lifetime (he is 60) was being named recipient of The Daniel Guggenheim Medal for 1958.

The Medal is given annually by The Daniel Guggenheim Medal Fund, Inc., to honor persons who make notable achievements in the advancement of aeronautics. Mr. Littlewood was the unanimous selection of the Medal Board of Award and received the distinguished honor "for leadership and continuous personal participation over a quarter of a century in developing the equipment and operating techniques of air transport."

Recognized as a leading air transport engineer, the President-elect has made basic contributions to many widely used commercial aircraft, among them the DC-3, DC-4, DC-6, DC-7, Convair 240, as well as many earlier airplanes, and the latest turboprop and jet transports.

Mr. Littlewood is a member of the NASA Industry Consulting Committee and the Committee on Operating Problems, and of the ATA Engineering Committee. He is also Chairman of the NASA Subcommittee on Aircraft Noise and of the ATA Joint Committee on Proximity Warning and Collision Avoidance Systems. In addition, he serves as Chairman, Advisory Panel on Aeronautics, Office of the Assistant Secretary of Defense (Research and Engineering).

Notable Aviation Career

Mr. Littlewood's career in aviation began in 1927 with Fairchild Engine Corp., where he became General Manager.

He joined American Airways in 1930, and, when the firm was reorganized in 1934 as American Airlines, he remained as Chief Engineer, becoming V-P—Engineering 3 years afterward.

In 1935, he received the SAE Wright Brothers Medal for an "outstanding contribution to aviation," and in 1952 gave the 16th Annual Wright Brothers Lecture on invitation of the IAS, with which he became affiliated in 1936. In 1956, he received the Award of the Flight Safety Foundation for work in that field to which he has long been devoted.

William Littlewood

Mr. Littlewood was born in New York City on October 21, 1898, and was educated in Long Island public schools and at Cornell University. While an undergraduate at Cornell, he assisted on the staffs of the physics, mechanics, and machine design departments and was awarded the Sibley Prize, symbol of the highest rating in engineering studies, for 2 consecutive years.

After graduation in 1920, Mr. Littlewood spent 7 years in the machine tool and heavy machinery industries before going with Fairchild in 1927.

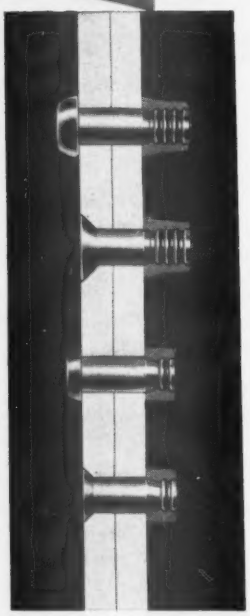
He is a former President of the Society of Automotive Engineers and served for 10 years as a member of the Main Committee of the National Advisory Committee for Aeronautics (now NASA).

Since 1948, he has been a director of the Cornell Aeronautical Laboratory in Buffalo. He has been President of the Cornell Society of Engineers and a Director and Vice-President of the Cornell Alumni Association, and currently is a Trustee of that institution.

Of the Institute's five elected officers for 1959, President Littlewood, Vice-President Johnson, and Treasurer Lederer are members of the Editorial Advisory Committee of AERO/SPACE ENGINEERING, the Institute's official monthly magazine.

XUM

Piercing the HEAT BARRIER!



TITANIUM HUCKBOLT* FASTENERS offer up to 43% weight saving, high strength at elevated temperatures, fast installation with uniform tension and low installed cost.

Titanium Huckbolt Fasteners can save as much as half a ton per average airframe with no compromise in strength or structural integrity.

Their excellent pull-together, high clinch and swaged lock assure maximum rigidity and elimination of vibration, stripping or shake out.

Installation is so simple that inexperienced operators can install fasteners accurately and uniformly at a rate that makes other fasteners expensive and obsolete by comparison.

Removal for service or repair is simple and without work damage.

*T.M. of Huck Manufacturing Company

For complete information—write or call licensees:

VOI-SHAN
MANUFACTURING COMPANY
A division of PHEOLL MANUFACTURING COMPANY
8463 Higuera Street • Culver City, Calif.
(Licensee)

HUCK
MANUFACTURING COMPANY
2480 Bellevue Ave., Detroit 7, Mich.

AIRCRAFT / MISSILE DIVISION
STANDARD PRESSED STEEL COMPANY
SPS
Jenkintown, Pennsylvania
(Licensee)

Licensed under Huck patents No. 2,527,307 2,531,048, 2,531,049 and 2,754,703

IAS Welcomes 30th Section

As a result of expansion in program and membership activity, IAS members in Antelope Valley—an area about 60 miles northeast of Los Angeles—have voted to assume full Section status. The Institute's thirtieth Section has taken the name of its geographical location and will be known as the Antelope Valley Section.

Study leading to the action began in 1957, under the leadership of M. J. O'Toole, of North American Aviation. Membership has grown steadily from an original 87 to a current 190 with participation of an additional twelve IAS members in the China Lake (Naval Ordnance Test Center) area.

Elected to posts as the Section's first officers were Chairman V. L. Allwardt, Convair; Vice-Chairman P. F. Bikle, Air Force Flight Test Center; Secretary Q. C. Harvey, North American Aviation; Treasurer R. B. Allan, Republic Aviation; Program Chairman J. Wesesky, AFFTC; Membership Chairman G. F. Miller, Jr., Convair; and Publicity Chairman H. E. Royston, Douglas Aircraft.

Members represent almost every major aircraft company in the United States that maintains flight-test activities within the area, either at Edwards Air Force Flight Test Center or at Palmdale Airport. Testing of latest model military and commercial aircraft is the daily occupation of most members; therefore, the ability to interchange certain information pertaining to development flight-testing techniques and to discuss mutual problem areas has proved a tremendous advantage to both members and industry.

During the last year, many interesting and beneficial meetings have been held. Guest speakers have included Col. Carlo Tosti, Major Ernest Davis, Keith Kinsey, Gordon Gettine, Major Dave Simmons, the late Capt. Iven Kincheloe, Jr., and others well known in the aero/space sciences.

Of great loss to the Section, the Institute, and aviation as a whole was the untimely death of Captain Kincheloe whose active participation has been keenly missed.

Necrology

Anatole M. Lambert

Anatole M. Lambert (A), who joined the Institute in 1946 as Senior Inspector for Boeing Aircraft Co., died May 20, 1958. At the time of his death, he resided in Santa Monica, Calif.

Hugh P. Hunerwadel

The USAF at Edwards Air Force Base, Calif., has reported the death on September 11, 1958, of Capt. Hugh P. Hunerwadel, USAF (M), an Engineering Test Pilot. He became a member of the IAS in January, 1958.

Douglas Promotes Raymond and Four Other IAS Members

Five IAS members, one an Honorary Fellow, were among several promoted by the Board of Directors of Douglas Aircraft Co. in October as it took steps to meet the growing requirements of its missiles and space programs.

Arthur E. Raymond (HF) was promoted to Senior Vice-President—Engineering.

New Vice-Presidents named were Edward F. Burton (F), Director of Transport Aircraft Systems Engineering; Edward H. Heinemann (F), Director of Combat Aircraft Systems Engineering; and Elmer P. Wheaton (AF), Director of Missiles and Space Systems Engineering.

Elected a Vice-President was S. P. Smith, General Manager of the Charlotte, N.C., Division.

Burton, Heinemann, and Wheaton will report to Mr. Raymond, whose position is a newly created one.

Two Corporate Members Merge Under New Name

The Ramo-Wooldridge Corp., an affiliate of Thompson Products, Inc.—both Corporate Members of the Institute—was merged into Thompson Products, Inc., on October 31. The name of the new company is Thompson Ramo Wooldridge Inc.

It was announced also that separation of Space Technology Laboratories from The Ramo-Wooldridge Corp. had been effected and that Louis G. Dunn, a Fellow of the Institute, had been elected President. Dr. Dunn had served STL as Executive Vice-President and General Manager since its inception in 1954.

Major Robert L. Oakley, USAF (M), was awarded the 1957 Leo Stevens Memorial Parachute Medal. He was honored for "having designed and developed a troop-type parachute which provided performance superior to the parachute previously used by the U.S. Army and Air Force personnel." Major Oakley is Assistant Chief, Parachute Branch, WADC. At left is Harold R. Harris, President of the Wings Club in New York, where the award was presented.

The name "Thompson Products" will be retained by Thompson's present automotive divisions. The names of Thompson Products, Ltd., Toledo Steel Products, the Ramsey Corporation, Bell Sound Systems, Dage Television, and Kolcast will all remain the same. The Tapco Group and Ramo-Wooldridge will retain their names and operate as divisions of Thompson Ramo Wooldridge Inc.

IAS *News* — *News of Members*

Brig. Gen. Milton W. Arnold, USAF (Ret.) (AF), has become President of the General Aircraft and Leasing Co., Inc.,—a new firm formed to deal in new and used aircraft and aircraft equipment.

Ward B. Dennis (M) has been promoted to Corporate Director of Development Planning, Northrop Aircraft, Inc., where he has been a member of the Development Planning staff.

Brig. Gen. H. F. Gregory, USAF (Ret.) (AF), has joined Midwestern Instruments, Inc., as Vice-President, Assistant to the President. General Gregory is a member of the Editorial Advisory Committee of AERO/SPACE ENGINEERING, Space Technology Panel.

Irving W. Halland (A), formerly with The Martin Co., has been named Sales Engineer, Missile Products Division, Beckman & Whitley, Inc., San Carlos, Calif.

Hugh Harvey (M), Aviation Representative for Shell Oil Co., has been transferred to the Public Relations Department, Shell Petroleum Co., London, England. He will handle public relations concerning technical subjects for the Royal Dutch/Shell Group.

William C. House (A), Director, Aerojet Systems Division, Aerojet-General Corp., has been granted a one-year leave of absence to serve with the Advance Research Projects Agency of the Department of Defense.

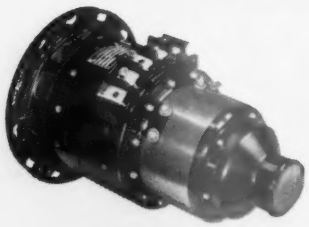
Ephraim M. Howard (AF), formerly Senior Staff Engineer at Marquardt Aircraft Co., has joined Aerojet General Corporation's Solid Rocket Plant as Technical Specialist on Special Assignment to the Manager of Applied Mechanics and Systems Division. Temporarily, he is acting as Head of the Fluid Mechanics and Heat Transfer in the Aerophysics Department.

Gordon W. Johnson (A), formerly Senior Project Engineer, Research, Inc., Minneapolis, Minn., has been appointed Director of Engineering at Pacific Magnetic Corp., Electronic Center, Romoland, Calif.

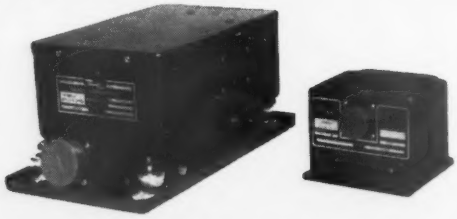
John A. Johnson (A), General Counsel of the Air Force since 1952, has been named General Counsel of the NASA.

James H. Kindelberger (HF), Chairman of the Board of Directors and Chief

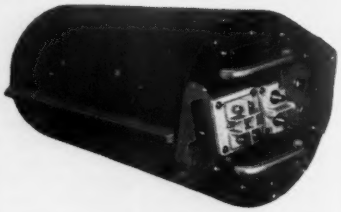
HIGH TEMPERATURE AC GENERATING SYSTEMS



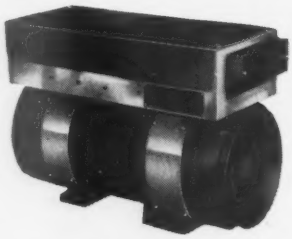
AC Generators



AC Voltage Regulators and SYSTEM COMPONENTS



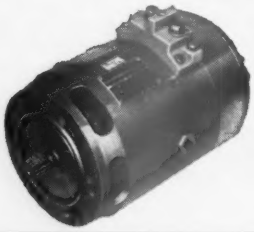
SPECIAL ENVIRONMENTAL FREE INVERTERS



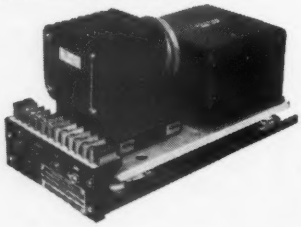
HIGH-ALTITUDE AND MISSILE INVERTERS

STATIC AC AND DC POWER SUPPLIES

HIGH TEMPERATURE DC GENERATING SYSTEMS

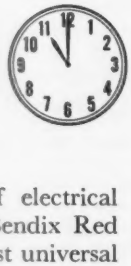


DC Generators



DC Voltage Regulators and CONTROL PANELS

BENDIX RED BANK—UNEXCELLED PERFORMANCE

AROUND THE  AROUND THE

There's no questioning the quality of electrical power equipment when it's made by Bendix Red Bank. The proof is in acceptance—almost universal acceptance. Twenty-four hours a day, in countries around the world, equipment like that shown above is proving that skillful design and expert engineering (plus an almost unmatched quality control system) can build an international reputation for dependable performance. If you can use quality like this, call on us for recommendations. Write today for brochure detailing our engineering, production, and service facilities, RED BANK DIVISION, BENDIX AVIATION CORPORATION, EATONTOWN, NEW JERSEY.

West Coast Sales and Service: 117 E. Providencia Ave., Burbank, Calif.
Canadian Affiliate: Aviation Electric, Ltd., P.O. Box 6102, Montreal, P. Q.
Export Sales and Service: Bendix International Division, 205 E. 42nd St., New York 17, N.Y.

Red Bank Division — Bendix AVIATION CORPORATION

Executive Officer, North American Aviation, Inc., is the recipient of the Carnegie Institute of Technology Distinguished Achievement Award for outstanding professional achievement.

William Marriott (A) is now Sales Manager, Military Sales, Cessna Aircraft, Washington office. He was formerly with The Martin Co. in the same capacity.

Erwin S. McCalla (A), formerly with Fairchild Engine Division, has joined Grumman Aircraft Engineering Corp. as Structural Test Engineer.

Albert Mooradian (M) has joined Raytheon Manufacturing Co., Guided Missiles Division, as Section Head of Design, Structures Branch. He was formerly with Pratt & Whitney Aircraft Division.

Capt. Sydney Sherby, USN (AF), who is retiring from the U.S. Navy and his assignment as Director of Naval Sciences Division, Office of Naval Research, has joined Hiller Aircraft Corp. as Vice-President of Engineering and Research.

Homer Joseph Stewart (AF), Professor of Aeronautics of the California Institute of Technology and Chief of the Liquid Propulsion Systems Division of the Jet Propulsion Laboratory of Caltech, has been appointed Director of the Office of Program Planning and Evaluation of the NASA.

G. Donald Welty (AF), Manager of Engineering Sales for Aluminum Company of America, has retired after 37 years with Alcoa.

IAS News — Corporate Member News

• **American Airlines, Inc.,** has announced the start of the first scheduled jet service across the United States. Daily nonstop flights between New York and Los Angeles will begin January 25; between New York and Chicago, January 23. By mid-1959, jet service will be initiated in San Francisco, Dallas, Boston, Baltimore, and Washington, D.C.

• **American Bosch Arma Corp.** has appointed Ernest A. Goetz Technical Assistant to the President. In this capacity he will continue as Chief Engineer of Arma Division. Kendall Clark has been named Manager of Military Engineering at American Bosch Division.

• **Amphenol Electronics Corp.** plans to merge with The George W. Borg Corp., Delavan, Wisc., into the Amphenol-Borg Electronics Corp., subject to approval at a special stockholders' meeting held December 30, 1958.

• **Bendix Aviation Corp.** has named J. M. Miller Director of Engineering for the Missile Section. He will direct all phases of engineering design and development for the Talos missile. Also appointed were: E. F. Lapham as Assistant Director of Engineering in charge of missile electronic systems design, systems analysis, advanced development, and project engineering effort; and W. E. Worley as Assistant Director of Engineering for design of the Talos ramjet, hydraulic add airframe system.

• **Cornell Aeronautical Laboratory** studies for the Army indicate the feasibility of constructing an apparatus to determine the static and dynamic flying characteristics of such small rotorcraft as flying jeeps and platforms. Since the Laboratory's inception in January, 1946, over $100 million have been spent for scientific research.

• **Curtiss-Wright Corp.** . . . The Electronics Division has appointed T. Courtenay Wakefield to the post of Chief, Systems Design.

• **Douglas Aircraft Company, Inc.,** has established a new organization designated Weapons Systems. Weapons Systems, incorporating Military Sales, was established to strengthen the management and direction of company military programs and to meet the challenge of increased competition. Charles R. Able, formerly Head, Military Sales, is Director.

• **Fairchild Engine and Airplane Corp.** reports acquisition of three Fairchild F-27B aircraft by Northern Consolidated Airlines. . . . Stratos Division has announced the appointment of A. J. Rizzi as Comptroller.

• **The Garrett Corp.** has elected Harry Wetzel, Jr., to the Board of Directors, filling a vacancy caused by the resignation of B. N. Snow.

• **General Dynamics Corp.** . . . Stromberg-Carlson has appointed Roy C. Ritchart as Assistant Chief Engineer, San Diego, Calif.

• **General Precision Equipment Corp.** . . . Librascope, Inc., has acquired Precision Technology, Inc., establishing a General Technology Department and expanding research and technical capabilities. R. Carroll Maninger is Director.

• **Goodyear Aircraft Corp.** is producing components ranging from center wing sections to radomes for Boeing B-52G missile platform bombers at its Litchfield Park, Ariz., plant.

• **Grumman Aircraft Engineering Corporation's** new biplane, the "Ag-Cat," has been designed specifically for the agricultural market as a crop-duster and sprayer. A wide variety of modern features have been incorporated into "Ag-Cat's" design. Specifications include an overall length of 24 ft., 4 in., wing span, 35 ft., 8 in., and height, 10 ft., 9 in. (see photo).

• **ITT Laboratories,** a Division of International Telephone and Telegraph Corp., has named T. C. Allen to the Nutley, N.J., headquarters as manager of professional staff relations, and Edwin P. Flanagan as manager of personnel administration for the California facilities at San Fernando and Palo Alto.

• **Lear, Inc.** . . . Lear Astronics Division has established a new engineering flight test center at Ontario, Calif., International Airport. . . . LearCal has opened a new sales and service office in Miami, Fla.

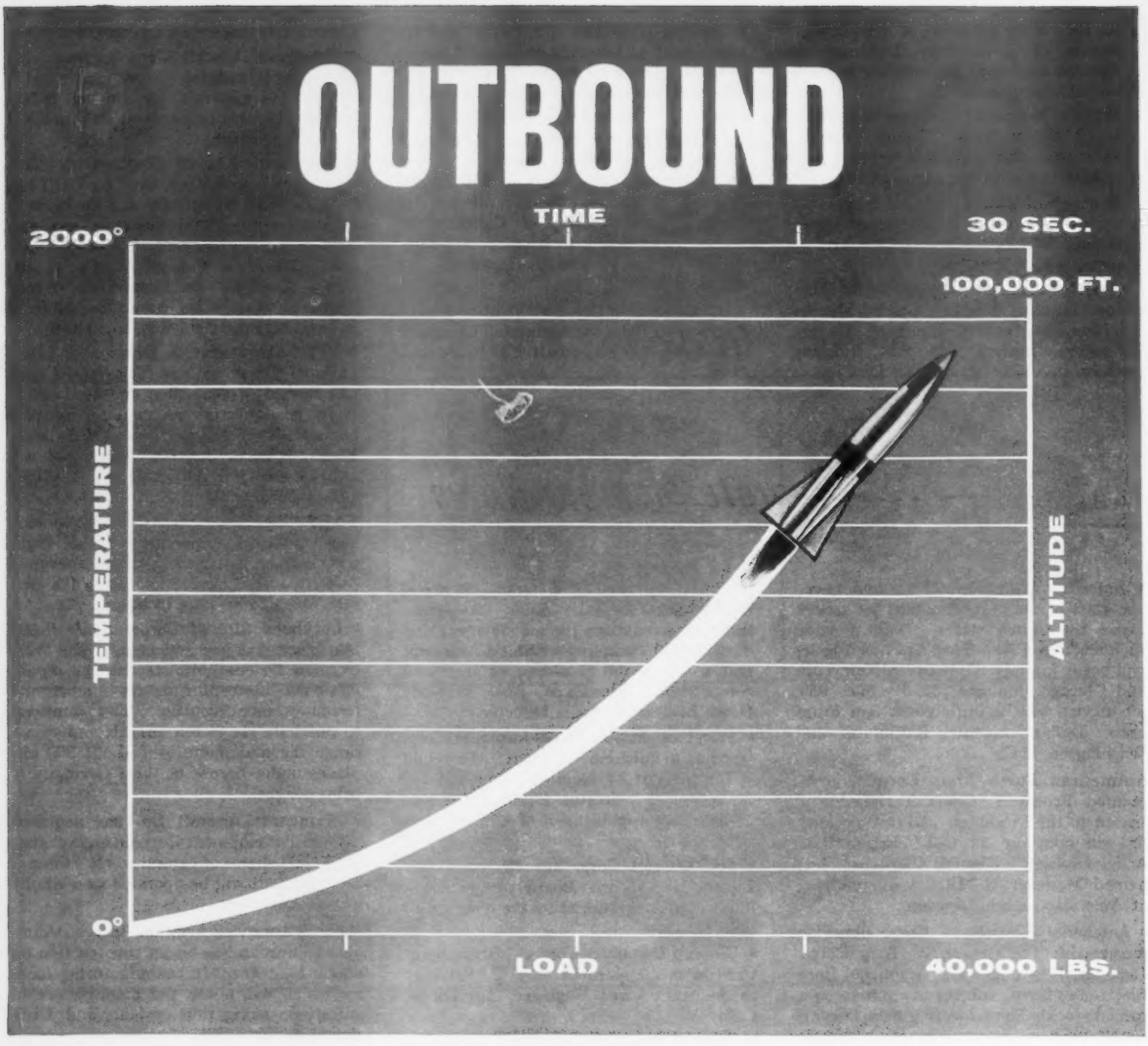
• **Lockheed Aircraft Corporation's** F-104 Starfighter has been selected by the West German Defense Ministry as the republic's basic interceptor, fighter-bomber, and reconnaissance airplane. The approval to purchase six to ten aircraft and to arrange the manufacture of about 300 airplanes under license in West Germany is being sought.

• **Marquardt Aircraft Co.** has acquired Cooper Development Corp. in an exchange for 60,000 shares of capital stock. Cooper Development will be operated as a wholly owned subsidiary.

• **North American Aviation, Inc.** . . . Autonetics Division has begun construction on a new 151,000 sq. ft. manufacturing facility which will house the manufacture of automatic navigation systems and Division personnel offices.

• **Pesco Products Div.,** Borg-Warner Corp., has elected Donald R. Spotz President and General Manager.

Grumman's "Ag-Cat" features the interchangeability of upper and lower wings, and all four ailerons; maintenance-free, spring steel landing gear; and a "sloping" nose that affords good visibility in normal flight attitude. Both the air-speed indicator and the engine tachometer are placed forward of the cockpit on a separate panel to minimize the pilot's eye focusing problem when flying in close proximity to the ground.



Second by second, higher-order performance is required of today's missile design—even as temperatures and loads are on the increase geometrically.

These are familiar problems to Shafer Engineers who have pioneered in the research and development of bearings to meet these higher-order requirements on many of today's outbound missiles. For example, Shafer research on the coefficient of expansion of materials—and the many other physical properties at elevated temperatures—establishes Shafer as a leader in high-temperature bearing design.

The famous exclusive design features that have made Shafer first choice for the toughest bearing applications in the airframe industry—greater capacity for its envelope dimensions and weight... integral self-alignment with full capacity...greater resistance to shock loadings and vibrations—may provide the answer to your missile control system bearing problems.

The time for you to draw on Shafer experience is now—before you lay in bearings on your latest missile design. And remember, too, Shafer advantages can provide important answers to bearing problems on ground support equipment as well as the "birds" themselves. Before you lay bearings in—call on Shafer experience.

Shafer Bearing Division, CHAIN Belt Company, Downers Grove, Illinois.

SHAFER BEARINGS

CHAIN BELT COMPANY

• **Solar Aircraft Co.** announces promotion of Armin F. Raebel to Chief Engineer. . . . Des Moines, Iowa, operations have been established as a fully integrated Division. Bruce A. Willsey, formerly manager of the Des Moines plant, is Vice-President and General Manager of the Division.

• **Stanley Aviation Corp.** has elected Major Gen. Frank O. Carroll, USAF (Ret.), a Director.

• **Westinghouse Electric Corp.** . . . Aircraft Equipment Department announced the formation of a new Space Technology Section which will be responsible for the development of advanced electrical systems and for the devices and products for flight vehicles associated with the space age. F. W. Lowry was named Sales Manager and N. F. Schuh, Jr., Engineering Manager.

IAS News

IAS Sections

Antelope Valley Section

(This Section—the Institute's thirtieth—is given a special welcome to AERO/SPACE ENGINEERING by placement in the IAS General News section. Please see page 15.)—*The Editors.*

Baltimore Section

York, Betts Speak

"**The ARPA Program**" was discussed by **Dr. Herbert F. York,** ARPA's Chief Scientist, at a classified meeting in October at the Westinghouse Air Arm plant. General Manager Sy Herwald initiated the proceedings with a warm welcome on behalf of Westinghouse. Chairman Bill Street introduced Dr. York.

A financial report was presented by Treasurer Martin Jackson showing a positive balance. Improved prospects for 1959 were predicted.

Another classified meeting was held early in November at the Aircraft Armaments, Inc., plant in Cockeysville, Md., and members were welcomed by J. Jacobsen in behalf of Aircraft Armaments. Program Chairman Marvin Kahn introduced **Brig. Gen. A. W. Betts,** Military Executive Assistant to the Director of Guided Missiles, who spoke on "**The Guided Missile Program.**" His observations on the history and status of several of the larger missile programs were augmented when, at the conclusion of the talk, a film displaying various missiles in the services' arsenals was shown.

L. ATRAN, *Secretary*

Boston Section

Airline Financial Problems

Dr. Paul Cherington, Harvard College of Business Administration, addressed members on "**The Financial Problems of the Airlines.**"

He said that the major airlines of the United States have undertaken a 4-year expansion program, beginning in 1959, to replace their current piston-type equipment with pure-jet and prop-jet aircraft. A capital outlay of almost $4 billion will be needed to order and place in service this new type of air transport equipment. How the new capital will be raised, the problems it presents, and the chances for success formed the core of the rest of Dr. Cherington's talk.

J. J. KIRBY, *Secretary*

Dayton-Cincinnati Section

Vanguard Program Reviewed

On October 21, 1958, **Donald J. Markarian,** Operations Manager of Project Vanguard for The Martin Co., presented a review of the Vanguard program to approximately 90 members. Mr. Markarian's detailed account of the objectives and accomplishments of the Vanguard program was accompanied by a film presentation of missile operations.

Mr. Markarian observed that when Project Vanguard began in late 1955, the United States did not possess a rocket system capable of raising a scientific satellite payload to the proper altitude (some 300 miles), boosting it to the necessary velocity (almost 18,000 m.p.h.), and controlling its angle at terminal velocity within the two degrees limitation required for a successful orbit.

He said one of the objectives of Martin's three-stage Vanguard design was near-maximum efficiency. The 22,600 lb. vehicle has a mass ratio approaching 90 per cent, and the thrust of its engines (totaling only about 37,000 lbs.) has been utilized so carefully that the complete weight it places in orbit (counting the empty final-stage rocket) is more than 70 lbs.

He went on to say that, considered individually, each stage of Vanguard has a creditable flight record, and, although the first four three-stage Vanguards produced only a single orbiting satellite, the really significant fact is that the previous ground and flight tests had been so successful that satellite instrumentation could be added to these test vehicles with a reasonable chance of a "bonus" orbit.

Mr. Markarian also commented that major Vanguard components and techniques have already been adapted for use in the Thor-Able re-entry rockets and the Air Force's lunar probes; and they will almost certainly find other applications in man's early efforts at space exploration. Perhaps of equal importance is the experience gained on the program with low-temperature, hypergolic, and solid-grain propellants.

D. F. JAMISON, *Secretary*

Detroit Section

Officers Elected

Newly elected officers are *Chairman,* Richard Chute, Chrysler Corp., Gas Turbine Research; *Vice-Chairman,* Fred J. Wilhoff, Continental Aviation and Engineering Corp., Turbojet Engine Group; *Secretary,* William M. Spreitzer, General Motors Corp., Research Laboratories; and *Treasurer,* Frank L. Moncher, Vickers, Inc., Aero Division.

WILLIAM M. SPREITZER, *Secretary*

Hagerstown Section

Weapon System Concept Debated

"**Planning to Meet the Weapon System Concept**" was the subject of an October talk by **F. E. Newbold, Jr.,** Vice-President—Planning, Fairchild Engine & Airplane Corp. Discussing changes in planning with which aircraft companies must contend, he observed that improving range, performance, or speed of a vehicle might not mean continuation of a contract because the thinking behind a weapon system could change, obviating the system.

Mr. Newbold added that future weapons systems would be of such magnitude that several prime contractors would of necessity participate in the design, development, and production of a single system.

A film on the first flight of the Fairchild F-27 concluded the meeting.

E. L. HARKLEROAD, *Secretary*

(*Continued on page 112*)

Forms Available, Competition Open Now for Flight-Test Engineering Fellowship

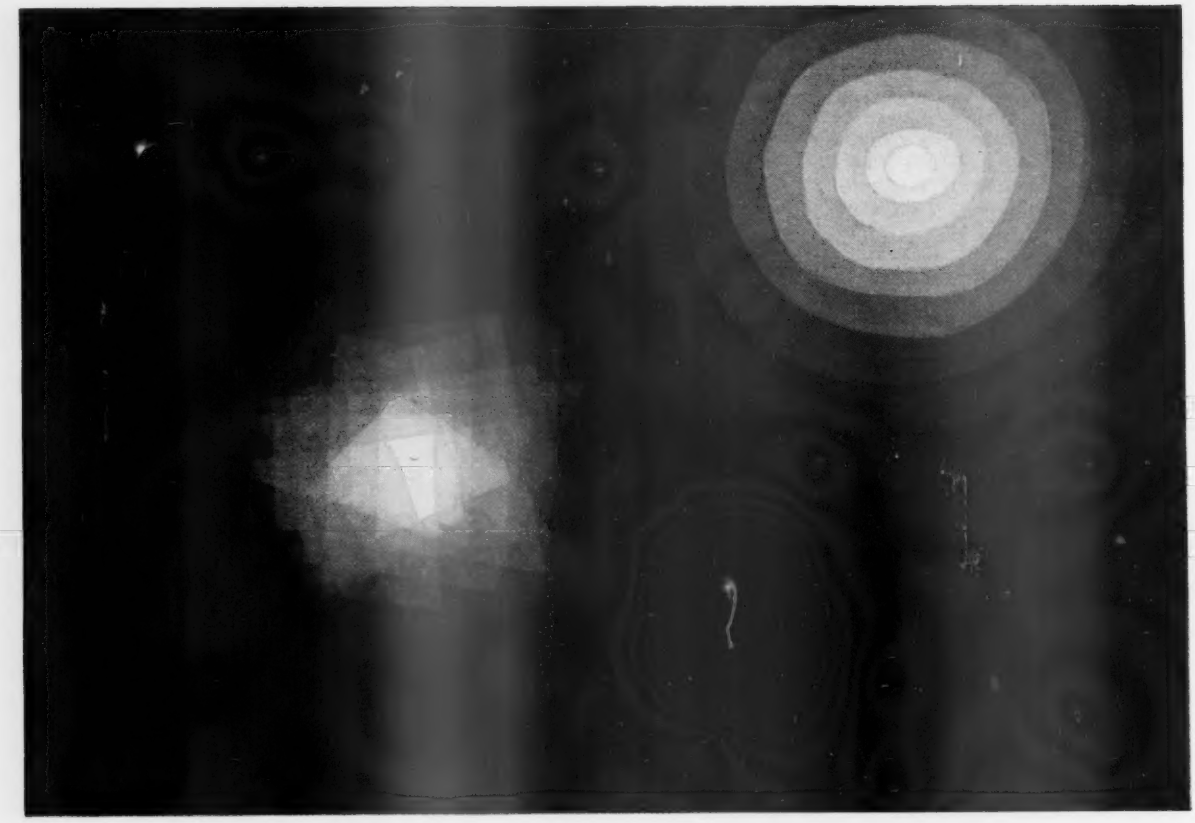
Interested in receiving an IAS Flight-Test Engineering Fellowship?

A Bachelor's degree in engineering and United States citizenship are the main qualifications for the 1959 competition—worth $7,300 over a 2-year period.

Write for applications now—closing date is March 1, 1959—to Flight Test, Institute of the Aeronautical Sciences, 2 E. 64th St., New York 21, N.Y. (This initial request should be endorsed by a sponsor.) Candidates may be enrolled in an educational institution or employed in industry when making application.

A First-Year Fellow receives a stipend of $1,500, $750 for tuition, and $850 for university departmental expenses. A Second-Year Fellow receives $2,000 stipend, $750 tuition, and $1,450 for departmental expenses. Second-Year renewal depends upon satisfactory performance during the first year.

XUM



"EARTH IN SPACE," one of a series of paintings of the planets by Simpson-Middleman, painters who have been finding their subject matter in science. To quote them: "Earth is distinguished among the planets by its oceans of water and its single moon. From these as a starting point, earth in this painting has been imagined as a configuration of intersecting planes—layer on layer of blue—until it becomes a transparent crystal, glowing in space." Painting courtesy John Heller Gallery, Inc.

Space power

The newest, most advanced Air Force missile project is Minuteman—a weapon system built around solid-propellant intercontinental ballistic missiles. Minuteman is under accelerated development for use by the Strategic Air Command, with the Air Force's Ballistic Missile Division managing the program.

Boeing is associate prime contractor for Minuteman assembly and test—an assignment that came to the company in recognition of its missile and system integration experience, its outstanding facilities and research capabilities. Boeing's organization, research and manpower resources have been geared to meet the complex technological needs of the space age.

Engineers and scientists at Boeing are at work on such advanced research and development projects as Dyna-Soar, and on studies for orbital, lunar and interplanetary systems.

Minuteman, Dyna-Soar and other advanced Boeing projects offer exceptional space-age opportunities to engineers and scientists of all categories. Drop a note to Mr. Stanley M. Little, Department A-82, Boeing Airplane Company, Seattle 24, Washington.

BOEING

DATELINE World

PROFESSIONAL NOTES AND REPORTS

Engineering and Scientific Briefs from Correspondents Around the Globe

Flight Tests Begun on Delta-Wing Bomber

◆ Flight tests on a new delta-wing supersonic bomber are under way in the Soviet Union, according to a West German press item. The aircraft is said to have six jet turbines for chemical fuels and to be similar to the North American XB-70. The Soviet designer of this new prototype is reported to be P. O. Suchoy.

Earlier, the same newspaper announced that, according to various correspondents, a Soviet bomber is being equipped with an atomic power plant. The thrust supposedly amounts to about 55,000 kg. The Soviet nuclear scientist Peter Kapitza has had a decisive role in the development, it is said.

These apparently unauthenticated reports are typical of the rumor and speculation rife in European press circles concerning Soviet developments in advanced aircraft.

Latvian Scientists Develop Metal Detector

◆ According to a Hungarian news item, Latvian scientists have developed a method by which the metal content of any mixture can be determined with great accuracy. The method involves application of a newly discovered material called "Tioxin," an extremely sensitive reagent capable of detecting microscopic amounts of metallic elements in soil, alloys, and various liquids.

Editorial Hints on Status, Plans for Electronics in U.S.S.R.

◆ A *Radiotekhnika* editorial, based on the decisions of the Plenary Session of the Central Committee of the Communist Party, in December, 1957, contains a number of interesting statements which partially reflect the present status and plans for future developments of some branches of U.S.S.R. electronics. Included in the planned development of means of communication during 1959–1965 is the "major problem" of developing powerful communication channels between the cities and economically related districts, especially those located in eastern U.S.S.R. The total power of the broadcasting stations will be increased considerably, parallel with the introduction of two-program ultrashort-wave broadcasting in European U.S.S.R. and in the most densely populated eastern districts. A large-scale improvement of existing broadcasting stations has been planned for 1959–1965. They will be converted for more effective plate- and plate-self-modulation systems, which will feature improved electroacoustical factors and will increase their present power output from 150 to 200 per cent. "Plate-self-modulation" (AAM) is believed to be an original U.S.S.R. development. In many radio stations, new metallic tower antennas of higher efficiency will be erected.

The U.S.S.R. manufactures UHF television transmitters having power of 2/1, 5/2.5, and 15/7.5 kw., for operation in the 48–100 mc. range. Two more transmitter types rated for 50/15 and 5/1.5 kw., with air-cooled tubes, are being designed for use in any of twelve television channels.

Communication systems using ionospheric propagation of ultrashort waves are said to be under development.

New equipment for radiocommunication includes automatic short-wave transmitters of 5 and 1 kw., with air-cooled tubes, which are operated by remote control, and duplex radio equipment for interdistrict communications.

Theoretical works during 1959–1965 will be aimed at solving the following "basic" problems:

(1) Multichannel communication systems using wave guides are seen as a possibility of accommodating thousands of communication channels.

(2) Mastery of millimeter-wave techniques and wave-guide design, including a flexible system for urban areas and routes having a hard profile design of efficient multiplex equipment.

(3) Barium titanate and Rochelle-salt dielectrics are mentioned among new materials considered as important for design of new equipment.

(4) Methods of direct conversion of solar energy into electrical energy are said to be in the stage of practical development.

(5) Thermal and photoresistors are seen as important components of future automatic and remote-controlled communication equipment. Temperature coefficients of 2.4 to 6 per cent per degree C. are given for industrially produced thermoresistors.

(6) Magnetic materials are considered as "extremely important"; Ferrocart was especially mentioned. Development of new magnetic materials is aimed at decreasing the dimensions and lowering the cost of equipment.

Two-Stage Future Aircraft Forecast by Soviet General

◆ Soviet references to two-stage aircraft are appearing with increasing frequency in both technical journals and press releases.

Among recent statements of the kind is a comment by A. N. Ponomarev, Lieutenant General of Engineering Technical Services. In a *Soviet Aviation* article on "Means of Progress of Aviation Technology," Ponomarev supports two-stage aircraft for the future and says that the first stage can be either a rocket accelerator or a plane carrier which will climb to a given altitude, where the rocket engine will take over and the second stage will start its function.

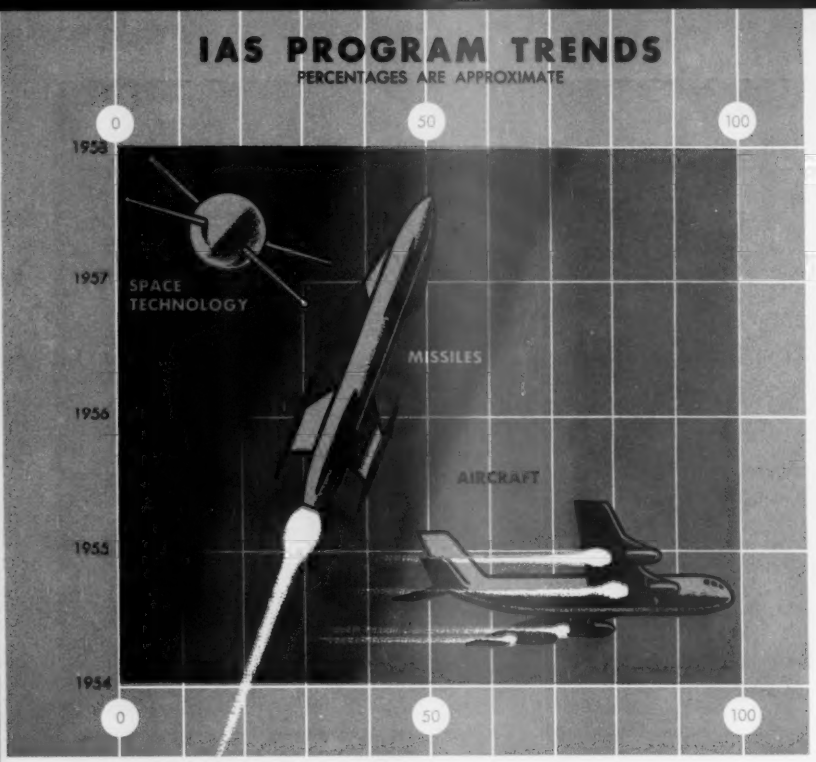
It is interesting to compare this two-stage theory with the views of another Soviet engineer, stated in the item following, which concern a combination power plant for hypersonic flight.

Combination Power Plant Planned for Hypersonic Flight

◆ With the comment that aeronautical experts throughout the world anticipate speeds of Mach 5 and above, Lt. Col. V. Parfenov, writing in *Soviet Aviation* magazine, announces that the Soviets have been planning a combination turbojet and ram-jet power plant for hypersonic flight.

Parfenov, an Engineer Candidate of Technical Sciences, explains that the turbojet engine cannot fly at hypersonic speeds above 20 miles and will be operated for take-off and climb only. When the speed reaches Mach 1, the ram-jet will take over. Greater efficiency will be achieved, he says, by a combination turbojet and liquid-propellant rocket engine. The article notes that pilots of hypersonic aircraft will breathe a mixture of 50 per cent oxygen and 50 per cent helium.

XUM



EDITORIAL

In mid-1958, IAS President Edward C. Wells appointed a Long-Range Planning Committee of the Council to study future plans and programs. For the use of the Committee, the Staff prepared a review of the record of the past 5 years. Excerpts from this report appear below.

THE 5-YEAR LOOK

A Progress Report

When the IAS was founded in 1932, its stated objective was "to advance the art and science of aeronautics." This primary objective has not changed in the intervening years. The generic term "aeronautics" has changed. Limitations of speed and altitude considered insuperable in 1932 have long since disappeared. Space flight is now an accomplished fact. The NACA has expanded into the NASA. The objectives of the IAS have also been broadened to keep pace with the changing times.

During the past year there has been a natural tendency to go overboard in the direction of space. The glamorous aspects of new capabilities of extending horizons have overbalanced certain sober realities. Although we are now reaching for the moon, air-breathing vehicles supported by the dynamic reaction of atmospheric air will be useful for a long time to come. Their capabilities have not been fully explored. The IAS, therefore, has a continuing obligation to serve its members in very large areas of interest which are not "out of this world."

For this reason, IAS objectives should continue to be slanted toward the maintenance of a well-balanced program tailored to fit the needs of the industry and the needs of scientists and engineers who are responsible for the development of all aspects of aero/space technology. The IAS has a clear mandate to serve the professional needs of its members in all flight regimes from Zero to Infinity.

An examination of the record of the past 5 years will show that IAS programs have been in phase with changing trends. In fact, it is always necessary for us to anticipate trends if IAS services are to be of value to the membership (see chart above). The fundamental sciences on which designers depend and the most advanced techniques for aero-space exploration will always be subjects for discussion in IAS meetings and publications long before any "hardware" has been developed.

In planning national programs, full advantage is always taken of the talent within the membership itself to determine proper subjects for discussion. The committees which have been established to advise on editorial policies for IAS publications have also been used regularly as advisers on national meeting programs. It has also been

our practice to go outside such committees (and even outside the IAS membership, if necessary) for advice and guidance in determining subjects of interest to IAS members. We are constantly seeking the best available people everywhere to participate in IAS programs.

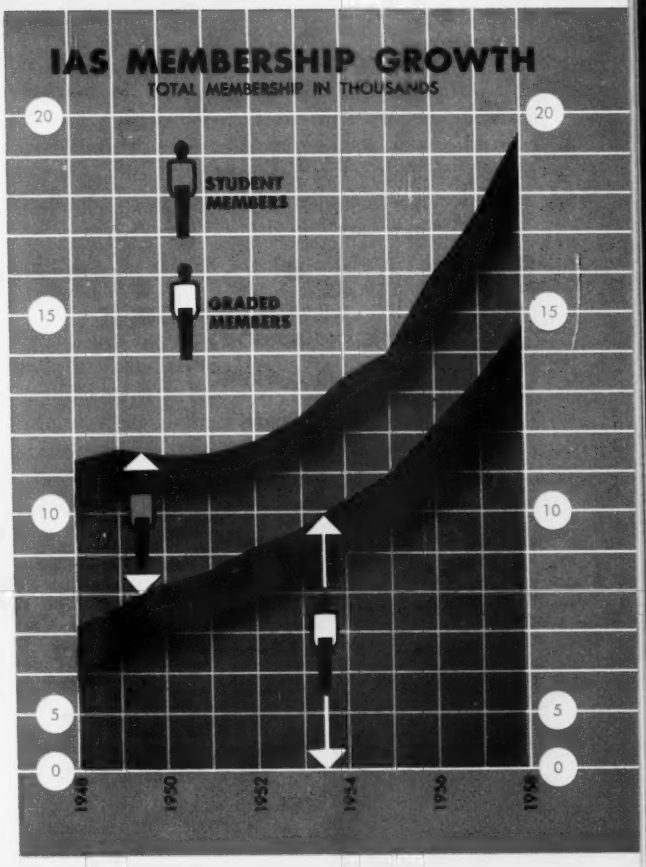
At the Section level, no effort has been made by the National organization to direct or to influence local program planning. Each Section has its own Program Committee. Such committees are in the best possible position to gage the needs of local membership and to provide programs consistent with local requirements.

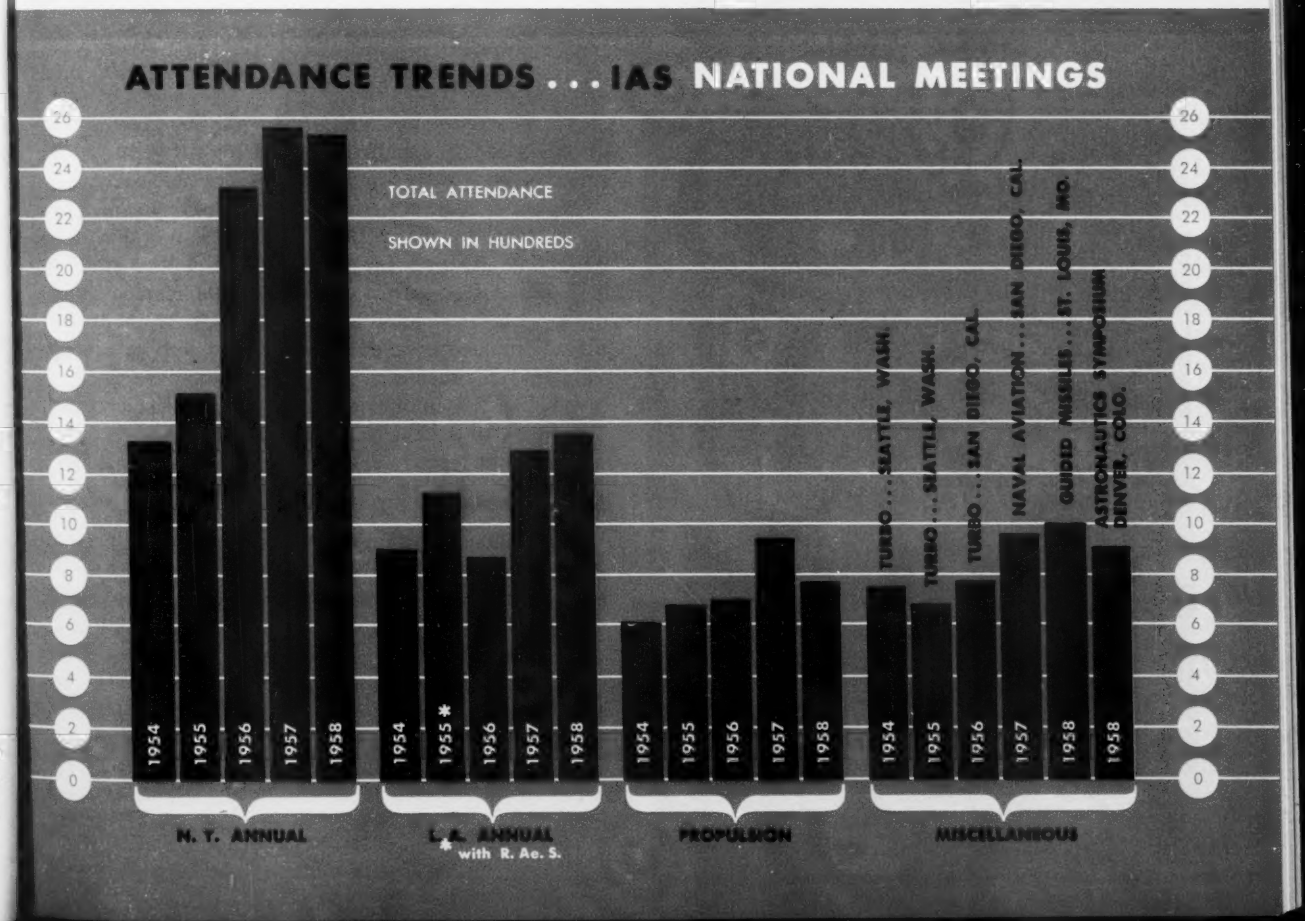
The most reliable indicator of "customer acceptance" of IAS policies and programs can be found in the trend of membership growth. Several facts stand out:

(1) No membership "drives" have been undertaken or encouraged by the National organization.

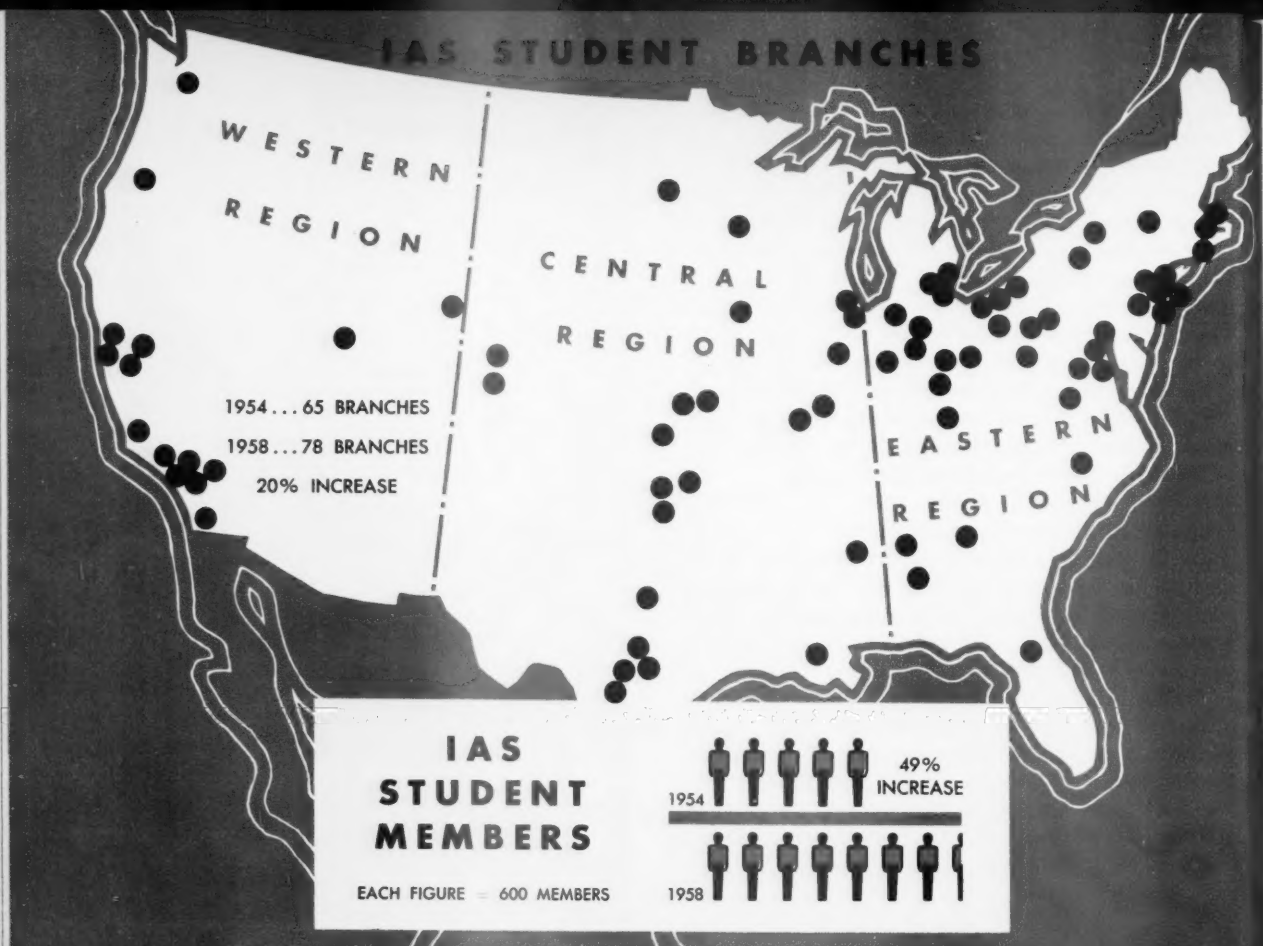
(2) During the past 5 years, the requirements for membership (new or change-in-grade) have been rigorously applied by a nine-man membership committee. Standards have been tightened all along the line, and have never been higher.

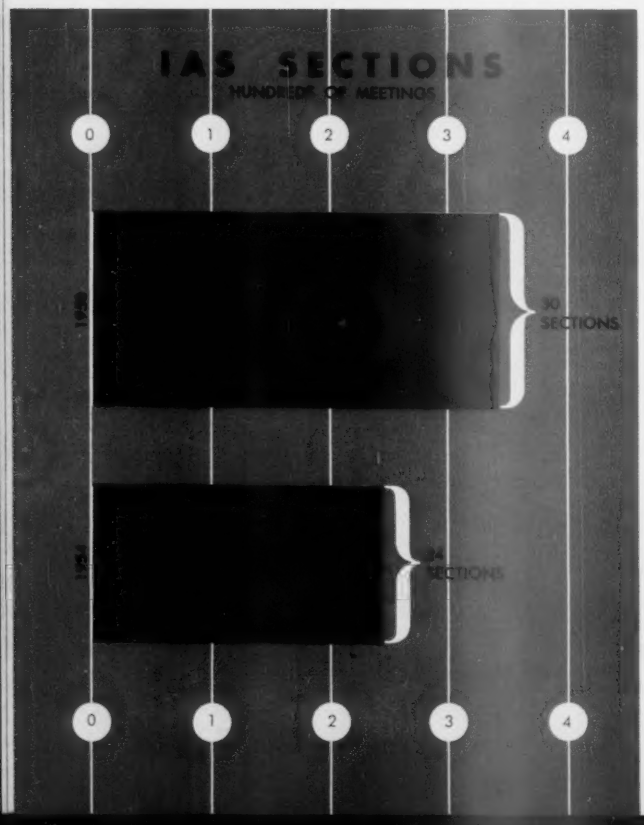
(3) The rate of increase in *net* membership has gone up in the past 4 years. As indicated in the accompanying chart (right), the average rate of net increase for the 3 years 1952–1955 was 608 members per year. For the 3 years 1955–1958, the curve climbs at a rate of 1,208 members per year. Current indications show a continuation at about the same rate.





XUM





(4) The years 1957 and 1958 show the greatest *net* increase in IAS membership in history—a gain of approximately 1,250 graded members for each year.

(5) Student membership reached a previous peak in 1948 because of the operation of the post World War II G.I. Bill. During the Korean conflict, the student population declined (as did our Student membership). Now, with emphasis on higher education for the scientifically minded, coupled with increased activity among engineering students at both the National and Section levels, IAS Student membership is again on the increase. The best estimate for 1958 puts the level close to 5,000—an all-time high.

National Meetings

IAS national meetings fall into three general categories: (1) those run exclusively by the IAS; (2) those cosponsored by the IAS and some other organization; and (3) those in which the IAS participation is at a less-than-sponsoring level. During the past 5 years, there have been 37 in category 1, 21 in category 2, and 17 in category 3.

It is obvious from the above that the IAS is operating on a collaborative rather than a competitive basis. It is felt that we should cooperate with any legitimate scientific group from which we can derive material to

fill the professional needs of IAS members. Over the years this collaboration has been extended into areas outside the United states—e.g., meetings with the Canadian Aeronautical Institute, the Royal Aeronautical Society, and the newly formed International Council of the Aeronautical Sciences (see AERO/SPACE ENGINEERING, November, 1958).

The number of attendees at any particular meeting is not necessarily a measure of the quality of the meeting program. An upward trend in attendance from year to year, however, may be taken as one indication of acceptability of programs by the membership. The comparative attendance at the four principal national meetings for the years 1954–1958 is plotted on an accompanying chart (p. 23).

Section Activities

It has been basic in the philosophy of management over the past 12 years that the real strength of the IAS depends upon the development of maximum activity and maximum strength at the Section level. The National organization exists largely to support the activities of its members in general and of IAS Sections in particular. Eighty-six per cent of the membership is now organized in the 30 IAS Sections.

Sections have been given a maximum degree of autonomy in organizing their own activities and in conducting their own affairs.

The National organization provides whatever support is needed for IAS Section operations and asks only that it be kept informed on Section plans so that duplication of effort or conflicts in schedules can be avoided. Coordination from the National office is supplied through direct communication in the form of a Section Officers' Newsletter and in Section Chairmen discussion meetings held semiannually at the time of the New York and Los Angeles Meetings.

Student Activities

During the past 5 years, the tempo of IAS Student activities has been tremendously expanded to keep pace with the rising requirements for scientific and engineering education in the aero/space sciences. The Institute now has an active branch in every college or university where the aero/space sciences are taught. About 5,000 students are organized in some 80 Branches. In 1954 the 60-odd Branches held some 390 (est.) meetings. In 1958 the 80 units held 780 technical meetings.

The availability of the Minta Martin Aeronautical Student Fund which came to the IAS in 1954–1955, together with such specialized funds as the Giannini Film Library Fund and the Flight Test Engineering Fellowship Fund (by an anonymous donor), has provided continuing financial support for the program.

The accompanying map and chart indicate the growth of the Student Branches between 1954 and 1958 and their distribution in the United States. The percentages indicated are not, however, a measure of activity. In terms of active participation, number of

meetings held, and number of papers presented, the increase is of the order of 100 per cent.

Each Section of the IAS has been urged to organize Student Activities Committees to study the student aid requirements and to encourage student participation in IAS affairs. In addition, close contact is maintained between National Headquarters, the Faculty Advisers, and the Student Officers. Operations Manuals for Student Branches are kept up to date, and coordination is effected by publication of periodic Faculty Advisers' Newsletters and Student Branch Newsletters.

One of the most important aspects of IAS Student Branch work has been the organization of annual Regional Student Conferences. At such meetings, students and their instructors and Faculty Advisers come together for presentation of papers, informal discussions, and vocational guidance programs. Prizes are awarded for the outstanding papers prepared by undergraduate and graduate students. These papers are then eligible for consideration for the National Minta Martin Prizes awarded each January at the National Meeting in New York.

In 1954, four Regional Conferences were held (Detroit, Texas, Southeast, and West Coast) with a total attendance of 160 students. The seven Conferences of 1958 (Detroit, Texas, Southeast, West Coast, Northeast, St. Louis, and Mid-Atlantic) attracted 840 attendees. A documentary film entitled *Advance and Be Recognized* was made of the 1958 Southeast Conference (Atlanta) and is available for showing at colleges and university Student Branches.

Library Services

The library and abstracting services have purposely been concentrating on filling the professional demands of the IAS membership for scientific and technical literature, with decreased emphasis on other, nontechnical aspects of aeronautics, including the historical. Growth in all library activities has been marked.

The growth in activity in N.Y. lending services (2,000 requests in 1954, 4,400 in 1958) has been accompanied by a decided shift in the nature of the material borrowed and in the type of borrowers. Circulation now is concerned entirely with scientific reports, periodicals, and books, which are sent to fill the demands of IAS Members, both Corporate and individual, and Government centers and universities engaged in research and development.

The number of abstracts published monthly in AERO/SPACE ENGINEERING and accumulated annually in the *Aeronautical Engineering Index* has risen significantly from about 4,500 in 1954 to almost 7,000 in 1958. Acceptance of the IAS efforts in this direction has been shown through contractual support by the U.S. Air Force of "International Aeronautical Abstracts" and through membership and industry purchases of the *Aeronautical Engineering Index* (500 copies of the 1956 edition were sold in the first $3^1/_2$ months following publication).

The Pacific Aeronautical Library, which operates substantially as an independent unit in the Los Angeles area with its own Advisory Committee and its own budget, is one of the most active technical libraries in the United States. It does not carry a large inventory of books, but it handles a large load of technical reports and provides day-to-day delivery service of needed reports and technical publications to its subscribers in the Los Angeles area. Its work-load has almost doubled in the past 5 years.

The Financial Picture

The IAS fiscal year runs from October 1 to September 30. The budget for each year is prepared by the Staff and presented to the Council for discussion, modification, and approval at the regular fall meeting (usually in October). At the same time, the financial accounts of the preceding year are reviewed by the Council in detail. Monthly operating statements are prepared by the Controller and reviewed by the Director. Summarized statements are reported to the Executive Committee and to the Council at each meeting.

During the past 5 years, the Institute has ended each year's operations "in the black." Budgets are drawn to plough back a maximum into services to members.

On the preceding page are two "pie" charts showing the general distribution of IAS Income and Expenses for the fiscal year 1957–1958. The totals vary from year to year, but the distribution of both income and outgo remains roughly the same. Note that individual Member dues and Corporate Member dues are approximately equal and that, combined, they make up only about one third of the Institute's total income.

The record of the past 5 years has been one of progress. Thanks to the interest of our members and the activity and cooperation of our Sections, IAS programs have been kept sufficiently flexible to meet the needs of rapidly changing times and techniques.

But we are not satisfied with the *status quo*. We think that we can do a better job in the future. We feel that, organizationally, the IAS can be made more flexible and more responsive to the wishes and needs of its members. For this reason the Director has submitted to the Council a proposal suggesting certain changes in its composition and method of selection, and a change in functions of certain elected officers with a view toward broader representation and better communications between the membership at large and management. This is now under active consideration by the Long-Range Planning Committee and has also been submitted to all Sections of the IAS for discussion. Suggestions from any member would be welcomed. Our single objective is to meet the professional needs of our members in the most effective way to the limit of our capabilities.

S.P.J.

Hydrogen and hydrocarbon fragments evolve, olefins and polymers form when jet fuels are exposed to nuclear radiation. These changes will affect the use of jet fuels in nuclear environments.

NUCLEAR RADIATION AND THE THERMAL STABILITY OF JET FUELS

J. T. Guerin, J. G. Carroll, R. O. Bolt, and J. A. Bert
California Research Corporation

In aircraft and missile propulsion, hydrocarbon fuels are being pushed to the limit of their thermal stability. Thermal degradation of the fuel can limit the performance of turbojet engines. If jet fuels are used to provide auxiliary thrust with nuclear-powered airborne vehicles, the influences of ionizing radiation on these materials must be known. The general effects of nuclear radiation on hydrocarbon fuels were reported earlier.[1] Appreciable changes in physical properties occurred above 10^8 roentgens (r). As the previous experiments were performed on 12-ml. samples, there was insufficient fuel for thermal stability tests. Accordingly, evaluation of this vital property was emphasized in this more recent test work.

Experimental Work

The nine production jet fuels described in Table 1 were chosen for the program. All fuels were straight-run distillates, except for the RP-1 and two of the JP-5's. The latter two stocks were highly paraffinic, essentially aromatic and olefin free. As shown in Table 1, the fuels are from various sources of crude petroleum. Thus, results have broad application as they include the influence of naturally occurring impurities, different hydrocarbon types, etc.

Most of the irradiations were made in the Canal Gamma Source at the Materials Testing Reactor (MTR). This source comprises fuel elements placed in a frame under 20 ft. of water for shielding. Exposures were in a $3\,1/2$ gal. aluminum tank, as shown in Fig. 1. A few exposures of the RP-1 were made by circulating a $3\,1/2$ gal. quantity in a kilocurie cobalt-60 source.[2] A 55-gal. drum (steel) of RP-1 was also irradiated with the combined neutron and gamma flux of the Nuclear Aircraft Reactor Facility (NARF) at Fort Worth, Tex. No attempt was made to exclude air or water from the samples either before or during irradiation.

Gamma dosages are expressed here in terms of the roentgen. Measurements were made[3] in the gamma sources by replacing the hydrocarbon sample with a monitor. In more familiar units of energy, 10^8 r $\cong$ 362 B.t.u. absorbed per lb. of hydrocarbon irradiated. This is valid even though the roentgen is properly applied only to gamma energy absorbed in air,[4] because the absorption characteristics of air and hydrocarbon are similar.[5]

The prevailing dose rate at the MTR varied tenfold to a maximum of 2×10^7 r/hr. Samples were exposed to nominal dosages of 1, 5, and 10×10^8 r as this was the range in which appreciable changes in physical properties occurred. Dosages reported are accurate to ± 10 per cent. For the sample of RP-1 exposed in NARF, the components of the combined reactor dosage were estimated together with an equivalent gamma dosage.[6] For those samples exposed in the cobalt-60 source, the dose rate was about 3.2×10^5 r/hr.

The physical and chemical properties of the fuels were measured by recognized procedures, as set forth in the Federal Test Method Standard[7] and ASTM Standards.[8]

In our tests, a CFR Fuel Coker[9–11] was used to determine if changes in thermal stability of fuels resulted from irradiations. As illustrated in Fig. 2, this device measured the tendency of jet fuels to form deposits on surfaces and to plug filters at high temperatures. It simulates the hot portion of turbojet

This research was sponsored in part by the United States Air Force under Contract AF 33(616)-3184, monitored by the Materials Laboratory, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio. The authors express their appreciation to N. P. Shiells of California Research Corporation for conducting the exposures in the cobalt-60 source and to D. L. Hunke of Phillips Petroleum Company for conducting irradiations in the MTR Canal Gamma Source.

Mr. Guerin is Research Engineer, Engine Fuels Division; Mr. Carroll—Research Engineer, Petroleum Products Research Division; Mr. Bolt—Senior Research Chemist, Petroleum Products Research Division; and Mr. Bert—Group Supervisor, Engine Fuels Division; all at the Richmond Laboratory.

TABLE 1
Properties of Fuels Tested

Property / Code	JP-4's					JP-5's			RP-1
	Westex	Salake	Mideast	Midcont	San Jo	East US	LA	Spcl	RP-1
Gravity, °API	53.7	51.0	50.4	53.8	47.3	48.2	37.5	48.0	44.3
Aniline Point	130	140	138	132	118	178	134	175	160
Distillation[a], % at °F									
Start	152	123	120	148	150	398	360	397	360
50%	300	350	364	308	329	439	434	438	424
90%	351	436	466	368	383	468	498	472	479
End	414	469	527	475	504	491	540	496	514
Aromatics[b], Vol %	9	11	12	8	10	0	22	0	5
Olefins[b], Vol %	1	Trace	3		2	0	Trace	0	0
Viscosity, cs at 0°F	1.70	2.31	2.38	1.68	2.09	6.94	7.01	6.60	5.18
Net Heating Value, Btu/pound (Calc)	18,680	18,620	18,715	18,720	18,540	18,840	18,445	18,820	18,660
Source of Crude	West Texas	Salt Lake (Rangely)	Middle East	Midcontinent	San Joaquin	Eastern USA	Los Angeles Basin	Special, Eastern USA	Highly Refined Kerosene

a. ASTM D 86 Method
b. FIA Method

engine fuel systems. The heated components of the CFR Fuel Coker are the preheater and the filter. Test conditions are expressed in three numbers—e.g., 400/500/6. The first number is the fuel temperature in °F out of the preheater, the second is filter case temperature in °F, and the third is fuel flow rate in lbs. per hour. For each fuel, test conditions were chosen so that the irradiated fuel could be tested at the same conditions as the original.

The results of the CFR Fuel Coker tests are expressed by two scales developed by the Coordinating Research Council (CRC)-Aviation Fuel Thermal Stability Group.[10] Filter plugging is expressed as "Filter Merit Rating" (FMR) on a scale from 0 to 99, in which 0 indicates immediate plugging and 99 indicates no plugging after a 5-hour test period. Preheater tube deposits are expressed as "Log of Deposit Function," a scale from 0 to about 5, where 0 indicates a clean tube and 5 indicates a tube completely coated with black deposit.

THERMAL STABILITY

JP-4 and JP-5 Fuels

Filter merit ratings are plotted as a function of gamma dosage in Figs. 3 and 4 for JP-4 and JP-5 fuels, respectively. These show that gamma irradiation in the dosage range investigated influenced jet fuel thermal stability measurably but not consistently. For example, three fuels showed reductions of 20 or more in FMR at the lowest dosage, four showed improvements, and one changed very little. At the intermediate dosage only one fuel had a lower FMR than its unirradiated sample. At the highest dosage FMR's on all irradiated stocks were higher than those on the respective original fuels.

Ratings of preheater deposits are shown graphically in Figs. 5 and 6 for JP-4 and JP-5 fuels, respectively. Deposits were not heavy for any of the fuels partly because of reduced test time and the relatively good thermal stability of most of the fuels used. Four of the JP-4's showed a tendency for more deposits at the lowest dosage, and all five were as good as or better than the original samples at the highest dosage. Of the three JP-5's, two formed no preheater deposits at 450/500/6, which are severe CFR Coker Test conditions irrespective of radiation dosage. For the third, irradiation improved both filterability and preheater coating to a marked degree at coker conditions of 400/500/6.

RP-1

Because thermal stability impairment was most evident at the lowest dosage used, 10^8 r, the RP-1 fuel was studied at dosages below this level. Initially, samples were irradiated in a circulating loop in the cobalt-60 source and statically in the MTR Gamma Canal Source for five dosages which varied 10,000-fold. As shown in Fig. 7, all of the irradiated samples had lower FMR's than the base fuel, except for the sample exposed to 10^8 r at the MTR. For the gamma irradi-

ated samples, a minimum FMR of 32 was obtained at 10^6 r. A subsequent test on the same irradiated sample run 5 months later yielded an FMR of 69. A barrel sample of the RP-1 was also exposed to reactor radiation to determine the effects of this environment. Tests showed a reduction in FMR to 20 for this sample, which received the equivalent of 10^7 r.*

Other Tests on Irradiated Fuels

During irradiation, hydrocarbons suffer a loss in hydrogen to form olefins which polymerize with further exposure. Such polymerization caused all the fuels to increase in viscosity with increasing gamma dosage. This trend is summarized in Fig. 8. Ten centistokes is usually considered a maximum viscosity for starting a jet engine. On this basis, the JP-5's, being more viscous than the JP-4's initially, became unsuited for use at 0°F. The JP-4's, though they showed a rate of viscosity increase similar to that for the JP-5's, were still acceptable for use at 0°F after the dosages shown in Fig. 8.

* 8×10^6 r of gamma, 3×10^{14} (epithermal) neutrons/sq. cm. and 5×10^{14} thermal neutrons/sq. cm. (see reference 6).

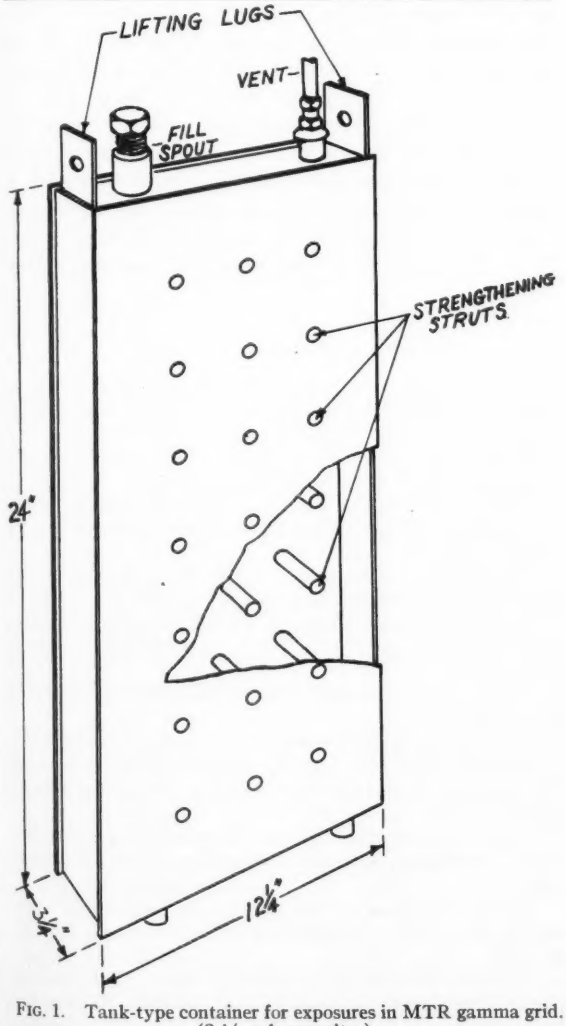


Fig. 1. Tank-type container for exposures in MTR gamma grid. (3 ½ gal. capacity.)

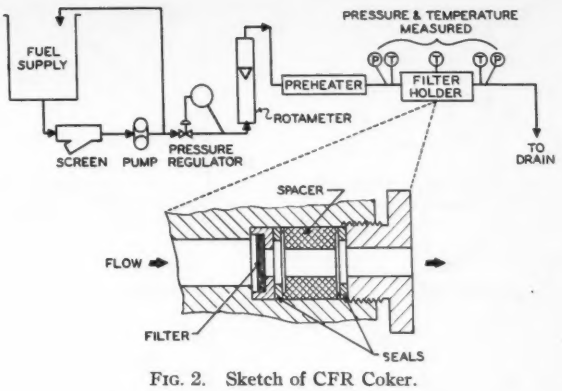


Fig. 2. Sketch of CFR Coker.

The volatility of the fuels changed significantly after irradiation. All irradiated fuels showed marked increases in materials boiling above the original 50 per cent point. Data for the highest dosage level are shown in Fig. 9. This effect was noted to increase with increasing dosage as a result of high polymer formation. The JP-5's also showed appreciable reduction in initial boiling point, reflecting low molecular weight radiolysis fragments. The JP-4's were a little changed in distillation below the 50 per cent points.

Other properties of the fuels were also altered by irradiation. A qualitative summary of these effects is in Table 2.

Discussion

Irradiation causes significant changes in the thermal stability of hydrocarbon fuels. At low dosage levels (10^4 — 10^8 r) thermal stability is reduced. Above 5×10^8 r fuel thermal stability is usually unchanged or improved. These observations are based on filter plugging, expressed as FMR, by thermally degraded products. The effect of irradiation on preheater deposits was not well defined.

The effect of gamma radiation on thermal stability appeared transitory in a sample of RP-1 irradiated to a dosage of 10^6 r. The first coker test made 24 hours after exposure gave a 32 FMR, a second test of the same sample 5 months later gave a 69 FMR. No aging effect was observed with the unirradiated material, although improvement in thermal stability with storage is not uncommon. This suggests that different fuels may have different critical dosages. Naturally occurring impurities and initial fuel composition due to a crude source do not appear to influence the effect of irradiation on thermal stability.

Gamma irradiation performed either statically in the MTR or in a circulating loop in the cobalt-60 source was about equivalent in the effect on thermal stability. However, on the basis of one sample, reactor radiation was more damaging than pure gammas for a comparable dosage.

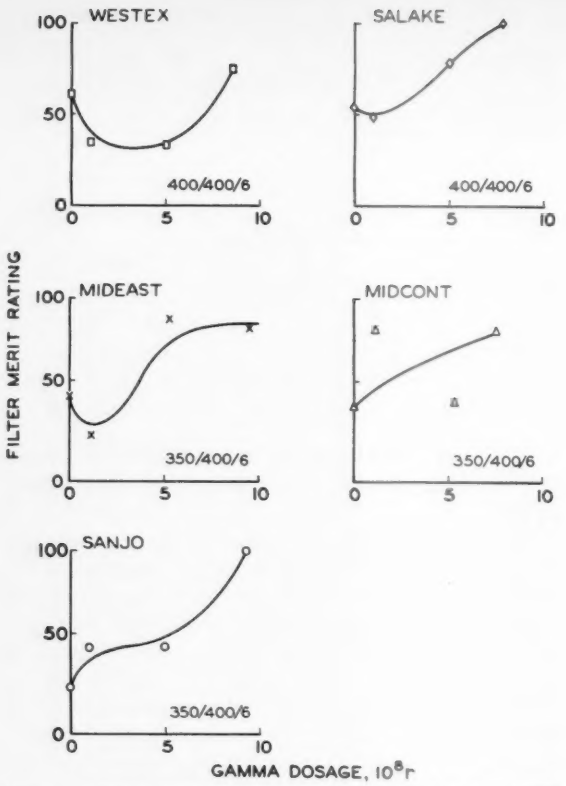


FIG. 3. Filter merit rating on irradiated JP-4 fuels. (CFR Fuel Coker.)

This apparent difference in radiation types appears to be larger than would be expected from errors in dosimetry, although other factors were not constant—e.g., storage time, temperature, and shipping. The presence of iron in the reactor sample could catalyze thermal degradation. Analysis showed 0.2 ppm. of iron, an amount not unusual in a fuel after considerable handling and storage in drums. In general, metals present in this amount tend to decrease thermal stability.

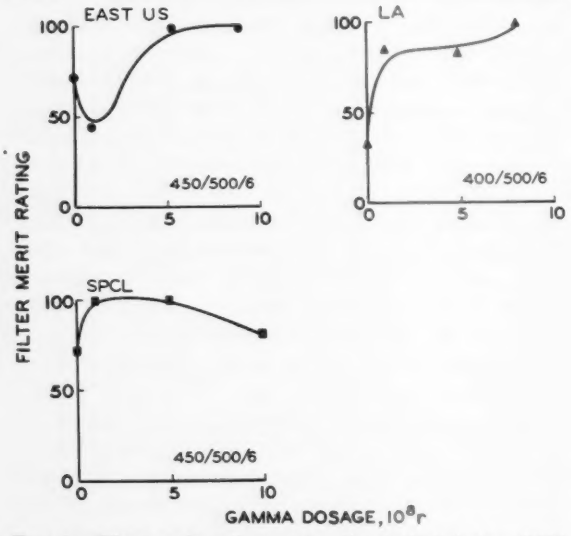


FIG. 4. Filter merit rating on irradiated JP-5 fuels. (CFR Fuel Coker.)

TABLE 2
Effect of Increasing Gamma Irradiation on Properties of Jet Fuels

Property	Effect
Density	Uniform increase
Gravity, °API	Uniform decrease
N_H, Hydrogen Atom Content	No significant change
Aromatic Content	No significant change
Olefin Content	Uniform increase
Suspended Gum	No significant change
Adherent Gum	No significant change
Heating Value	No significant change

Infrared spectra were obtained on all irradiated samples in an attempt to find differences in constituents. The resulting absorption traces were all practically identical. This showed that no change in composition, measurable by this technique, had occurred in any of the samples.

Above 10^8 r viscosity change becomes appreciable. JP-5 fuels can tolerate less dosage than the less viscous JP-4's before reaching the 10-centistoke level which restricts engine starting. Inherent resistance to radiation-induced thickening was about the same for the five JP-4's and three JP-5's from various geographical crude sources. The viscosity increase occurs because of the formation of high boiling components. For the JP-5's, hydrocarbons were also formed which had lower boiling points than those in the original fuels. It is likely that "light ends" were also formed during irradiation of the JP-4's but that they escaped through the vent line. Observation of other properties confirm earlier results.

REFERENCES

[1] Carroll, J. G., Bolt, R. O., and Bert, J. A., *A Survey of the Radiation Stability of Hydrocarbon Fuels*, Aeronautical Engineering Review, Vol. 17, No. 3, p. 61, March, 1958.

[2] Manowitz, B., *Use of Kilocurie Radiation Sources*, Nucleonics, Vol. 9, No. 2, p. 10, August, 1951.

[3] Hogg, C. H., *Gamma Ray Dosage Rate Measurements*, Office of Technical Services, USAEC Document IDO–16205, November, 1955.

[4] Lapp, R. E., and Andrews, H. L., *Nuclear Radiation Physics*, 2nd Ed., p. 127; Prentice-Hall, New York, 1954.

[5] Beta, H. H., and Ashkin, J., *Penetration of Gamma Rays*, Experimental Nuclear Physics, Vol. 1; John Wiley & Sons, New York, 1953.

[6] Private Communication with Personnel of Convair, Fort Worth, Tex.

[7] Federal Test Method Standard No. 791, December 15, 1955.

[8] ASTM Standards, Part 5, *Fuels, Petroleum, Aromatic Hydrocarbons, Engine Antifreezes*, American Society for Testing Materials, 1955.

[9] *Instructions for Operation and Maintenance of CFR Fuel Coker*, Coordinating Research Council Manual No. 3, March, 1957.

[10] *Report of the Panel on Data Analysis*, CRC-AFD Fuel Thermal Stability Group, Coordinating Research Council, January 16. 1956.

[11] *ASTM Standards on Petroleum Products and Lubricants*, prepared by Committee D-2, p. 1059, American Society for Testing Materials, November, 1957.

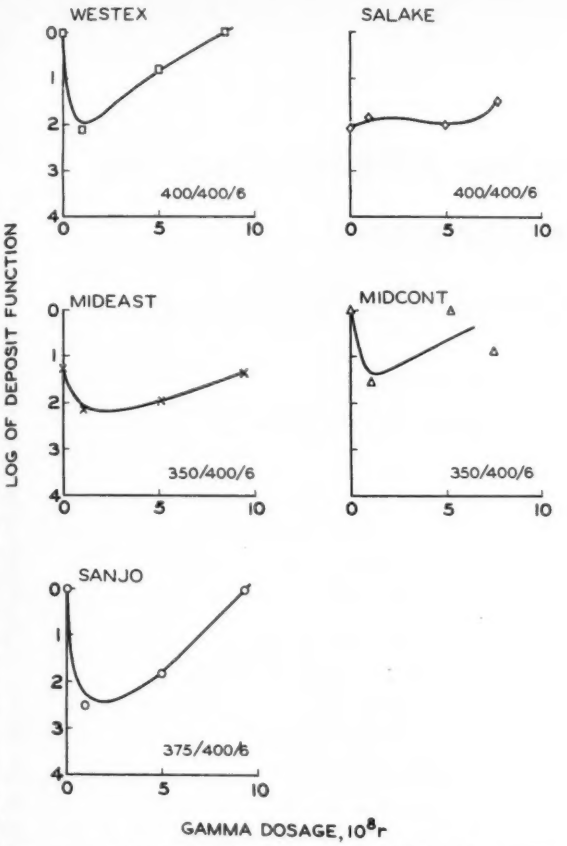


FIG. 5. Preheater deposit rating on irradiated JP-4 fuels. (CFR Fuel Coker.)

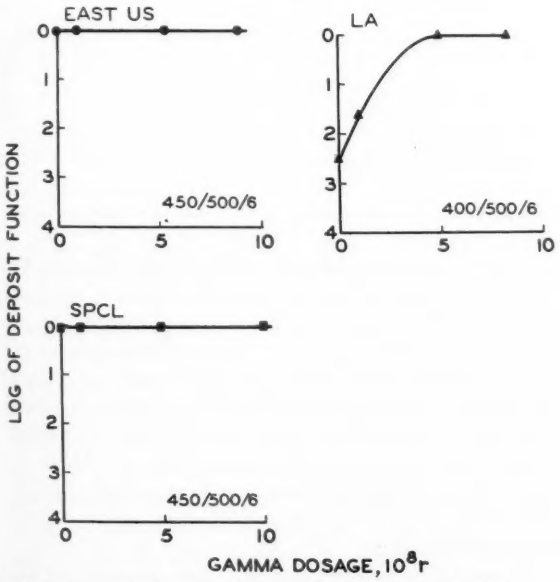


FIG. 6. Preheater deposit rating on irradiated JP-5 fuels.

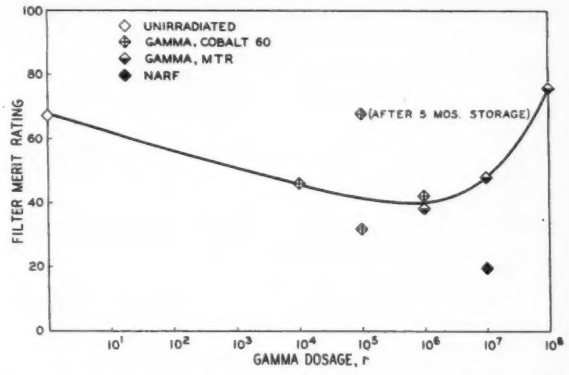


FIG. 7. Effect of radiation on thermal stability of RP-1 fuel. (CFR Fuel Coker 400/500/6, highly refined kerosene.)

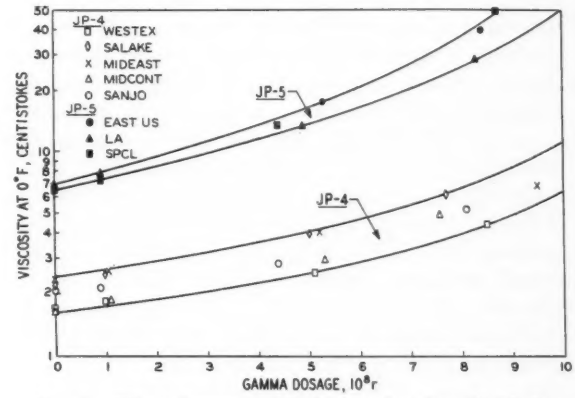


FIG. 8. Effect of gamma radiation on viscosity of jet fuels.

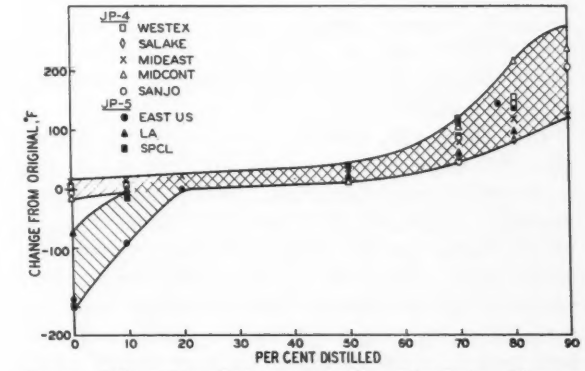


FIG. 9. Effect of irradiation on volatility of jet fuels. (Gamma dosages: 7.5 to 9.5 × 10^8 r, distillation: ASTM D 86.)

Lightweight engines are superior for short-range aircraft. Engines with low specific fuel consumption are best for long ranges.

Comparing Aircraft Engines by Mission Requirement and Aircraft Performance

E. William Beans
Pennsylvania State University

THIS ARTICLE presents a method of comparing aircraft engines based on aircraft performances and mission requirements. The basis of comparison is a parameter termed engine factor which is the ratio of the engine thrust to the weight of the propulsion system and the payload. The procedure is to make assumptions as to the aerodynamic characteristics of a standard airframe. From these assumptions the maximum speed, rate of climb, maximum altitude, and range can be determined for each engine as a function of aircraft weight. Since propulsion weight and payload are a function of aircraft weight, the above mentioned parameters are also a function of engine factor. The comparison of the engines is then made on a basis of the summation of the engine factors for each flight parameter at the required mission range.

INTRODUCTION

Aircraft engines are currently compared on the basis of thrust, fuel consumption, and engine weight. This is rightly so for higher thrust means increased performance, a lower fuel consumption results in a longer range or endurance, and a lighter engine leads to a lower propulsion system weight and a lighter airplane. Hence, such ratios as specific fuel consumption and specific weight (W_e/F) are useful parameters in making engine comparisons.

It is conceivable that for a given application an engine with a low specific weight and high specific fuel consumption—i.e., rocketplane, could result in a higher performance airplane than one which uses an engine with a higher specific weight and lower specific fuel consumption. Therefore, a parameter which relates specific weight and specific fuel consumption would be useful in engine comparison studies. This paper deals with such a parameter which has been termed engine factor.

Mr. Beans is Instructor in Mechanical Engineering. He was formerly associated with North American Aviation, Inc.

SYMBOLS

F	=	Engine thrust
D	=	Airplane drag
L	=	Airplane lift
W	=	Airplane take-off weight
W_p	=	Propulsion weight and payload
W_e	=	Weight of engine
W_l	=	Weight of payload
W_t	=	Weight of airplane fuel
W_f	=	Fuel consumption
S	=	Wing area
M	=	Mach Number
K	=	Wing loading
C_D	=	Coefficient of drag
R/C	=	Rate of climb
R	=	Range
p	=	Ambient pressure
a	=	Sonic velocity
h	=	Altitude
E	=	Engine factor
δ	=	Ratio of ambient to sea level pressure
α	=	Angle of attack
γ	=	Ratio of specific heats
$f(\ )$, $\phi(\ )$, $G(\ )$	=	Functions of ( )

Engine factor is defined as the thrust of an engine divided by the propulsion weight plus the payload. The propulsion weight is the weight of the engine plus the weight of fuel onboard. The payload is considered as the weight of the crew plus the armament. Based on present design theory and existing airplanes, a relation between airplane gross weight and propulsion weight plus payload can be shown (Fig. 1). With the relationship presented, airplane performance can be estimated in terms of "engine factor" for any given engine and payload.

It should be pointed out that the estimates of airplane performance obtained are just for the comparison of engines and will probably vary greatly from the actual performance obtainable with such engines

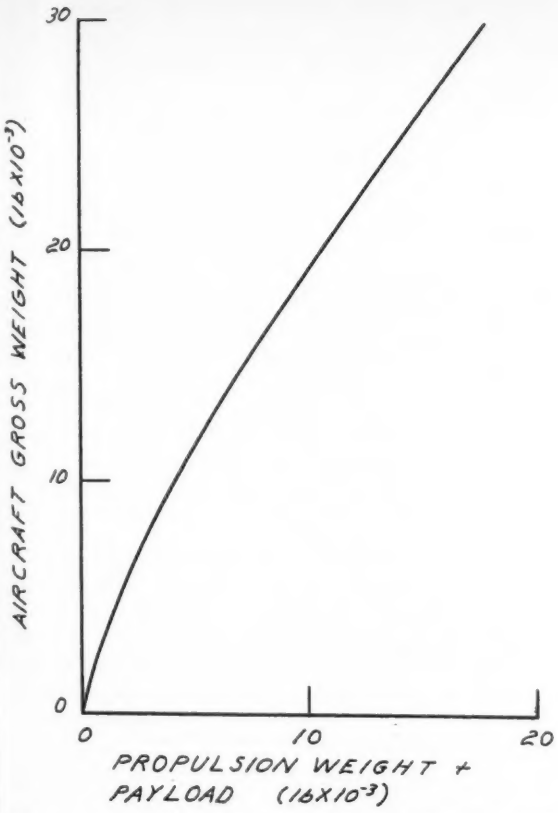


FIG. 1. Aircraft gross weight vs. propulsion weight and payload.

A comparison of this method to the performance of existing aircraft showed the difference to be in the order of 10 per cent. This error is of little interest since we are only interested in the performance as a means of comparison. It is felt that differences in performance obtained are of the right order of magnitude.

METHOD OF ANALYSIS

The airplane performance on which engine comparison is based is maximum speed, rate of climb, range, and maximum altitude. By making certain assumptions pertaining to the aerodynamics of the airplane, it is possible to estimate the above parameters as a function of engine factor. The flight regimes in which the above parameters are to be compared should correspond to the application under consideration.

For illustrative purposes, consider the selection of a power plant for a high-speed high-altitude interceptor. With this application in mind, a maximum comparison of engines will be based on the following conditions: maximum speed in level flight at 60,000 ft., rate of climb at 50,000 ft., range at 40,000 ft., Mach Number 0.9, and maximum altitude.

The following assumptions were made from existing design data for an aircraft in this flight regime:

(1) Since the comparison is for an interceptor type of mission, the payload is considered to be a constant for all aircraft.

(2) All airplanes in the study are aerodynamically similar and have a constant wing loading. Airplane size is directly proportional to airplane weight.

(3) Subsonic C_D is considered constant, and supersonic C_D is considered constant.

(4) A maximum L/D ratio is selected.

(5) Loss in airplane weight due to fuel consumption is not considered.

With these assumptions, equations relating engine performance to flight performance can be obtained.

Maximum speed

Equating thrust to drag

$$F = D = C_D p \gamma S M^2/2$$
$$S = W/K$$
$$F = (C_D p \gamma/2K) W M^2$$
$$M = \sqrt{(2K/C_D p \gamma)\,(F/W)}$$

Since $W = f\,(W_p)$ (Fig. 1), M is proportional to $\sqrt{F/W_p}$ or $M = f_1(\sqrt{E})$.

RATE OF CLIMB

$$R/C = (\text{thrust hp} - \text{drag hp})/W$$
$$R/C = (aM/W)(F - D) =$$
$$(aM/W)\,[F - (C_D P \gamma W/2K) M^2]$$
$$R/C = aM[(F/W) - (C_D p \gamma/2K) M^2]$$

or $R/C = aMf_2(E) + G(M^3)$

Again, it can be seen that rate of climb is a function of "engine factor," or R/C is proportional to E.

RANGE

$$R = Mat$$
$$t = W_t/W_f$$

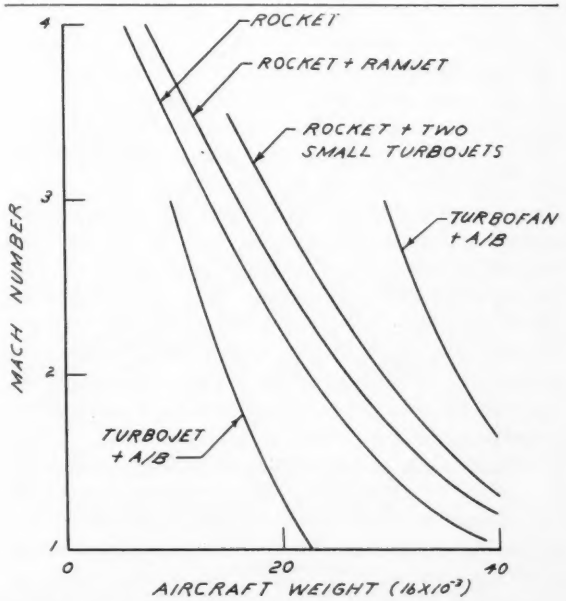


FIG. 2. Mach Number vs. aircraft weight for maximum speed condition.

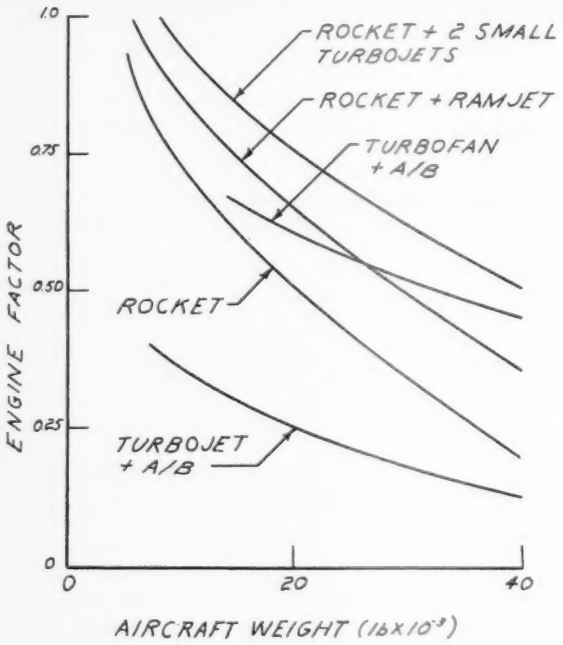


FIG. 3. Engine factor vs. aircraft weight for maximum speed condition.

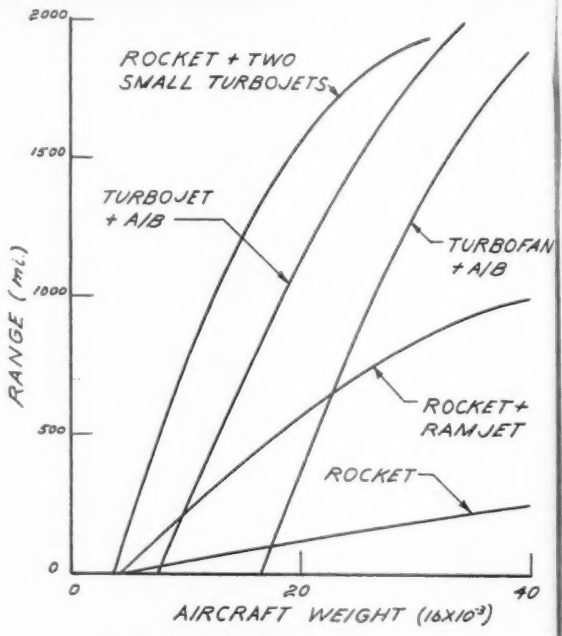


FIG. 5. Range vs. aircraft weight.

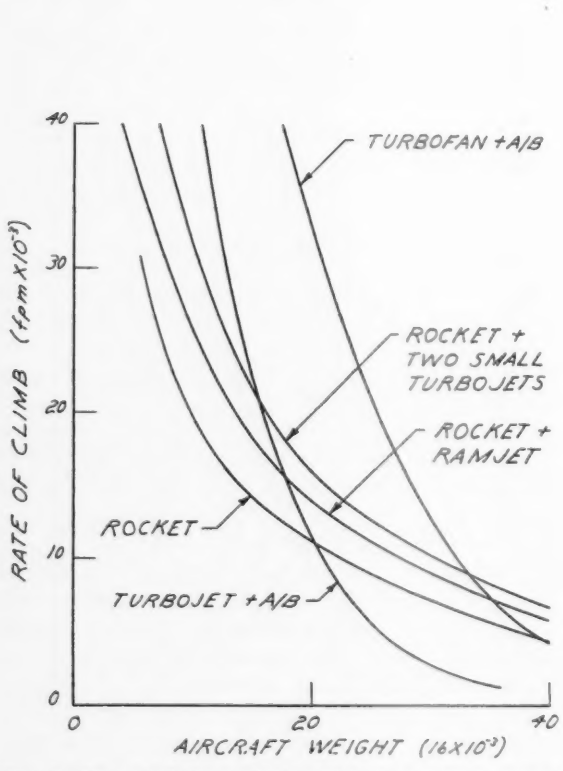


FIG. 4. Rate of climb vs. aircraft weight for maximum rate of climb condition.

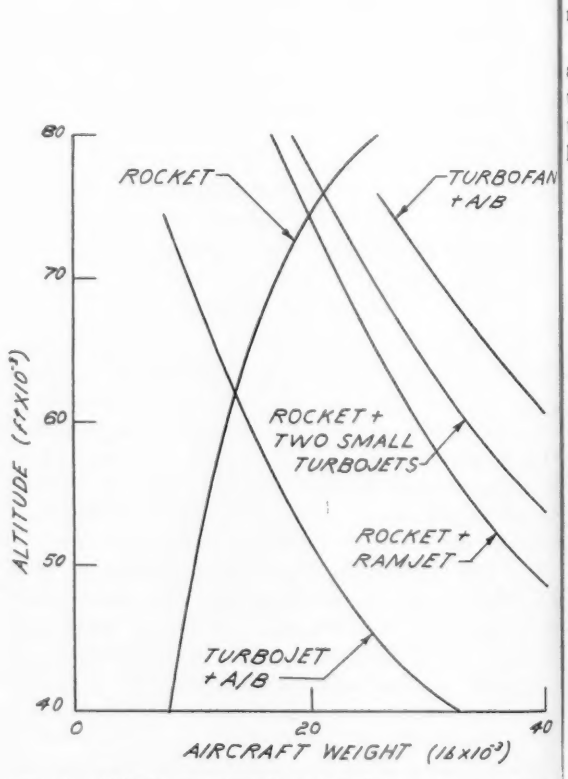


FIG. 6. Altitude vs. aircraft weight for maximum altitude condition.

$$W_t = W_p - (W_c + W_f) = G(W)$$
$$W_f = \phi(F)$$
$$R = Ma[G(W)/\phi(F)] = Ma/f_3(E)$$

Here it can be seen that R is inversely proportional to E.

Maximum Altitude

For $R/C = 0$, $\alpha = 0$
$L/D = W/D$
$D = F$

For airbreathing engines above 35,000 ft. and at the same Mach Number the ratio F/δ can be taken as a constant.

$$L/D = W/(F\delta/\delta)1$$
$$\delta = [1/(L/D)\ (F/\delta/W)] = f(h)$$

or δ is proportional to $1/E$. The relation between h and δ is such that δ decreases as h increases. Hence, $h = f_4(E)$.

The thrust of airbreathing engines decays as altitude increases, therefore the engine factor for aircraft of the same weight will also decrease with increasing altitude. Since high altitude is a desirable feature if the thrust for all altitude comparisons is taken at the same altitude, say 35,000 ft., then, as E_{35} increases so will the altitude.

Hence it can be concluded that as the engine factor increases, the maximum speed, maximum altitude, and rate of climb will increase, while the range will decrease.

The types of power plants considered in this example are: rocket; ramjet plus rocket; rocket plus two small turbojets (high s.f.c., low specific thrust); turbojet plus A/B; and turbofan plus A/B (low s.f.c., high specific thrust). The thrusts of these power plants

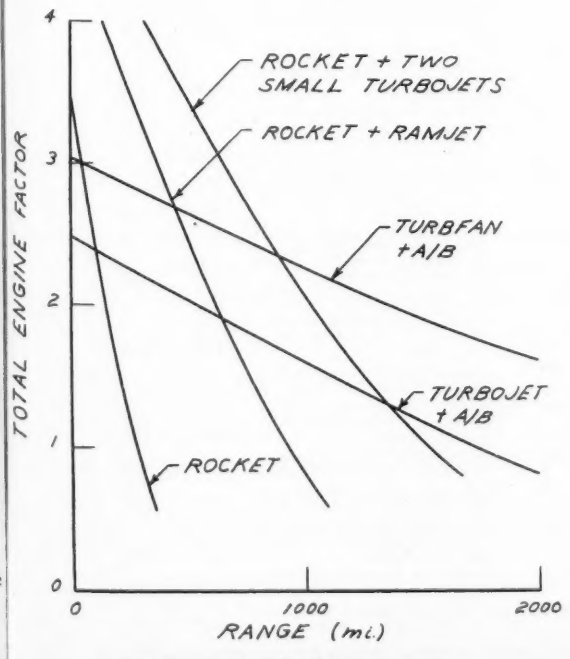


Fig. 7. Total engine factor vs. range.

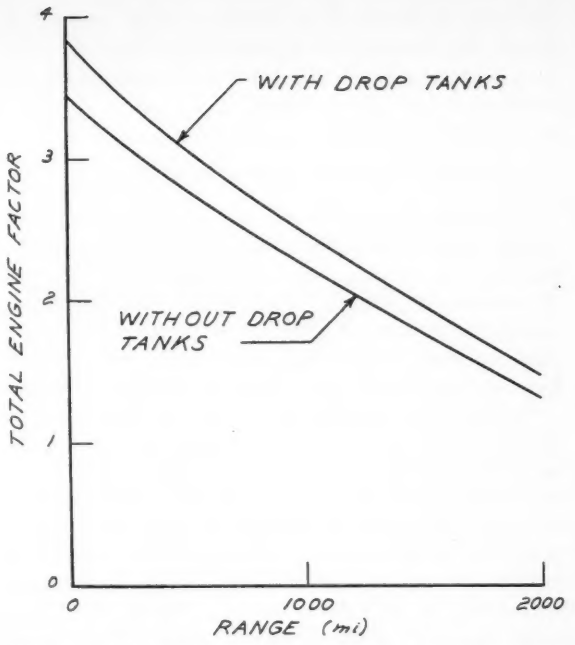


Fig. 8. Total engine factor vs. range for aircraft with and without drop tanks.

are not equal to each other but vary over a small range. This was done for the reason that in a real situation it is not likely to have power plants of the same thrust.

The thrust characteristics are fixed with the selection of the power plant. Therefore, the engine factor of a particular engine installation can only be varied by changing the propulsion weight, hence the airplane weight. With the equations developed in this paper, the change in the flight parameters with increasing airplane weight can be computed, and, likewise, the relationship of engine factor and airplane weight. Figs. 2 and 3 are examples of these relations for the maximum speed condition. Figs. 4–6 illustrate the change in rate of climb, range, and maximum altitude with airplane weight. Since these parameters vary directly with engine factor, their relation of engine factor to weight would be similar.

With a set of these curves, the performance of aircraft of the same weight can be estimated for each power plant. It would be expected that no one of these engine airplane configurations would have the greatest performance in each of the four flight conditions. For example, the rocket plane would probably exceed in maximum altitude and rate of climb but have the poorest range. So the question still remains which power plant for a given weight produces the best aircraft. If the engine factors for each of the parameters are added together, then this sum is an indication of the general performance of the aircraft.

The only advantage obtained in increasing the airplane weight, payload being constant, is greater range; all other parameters decrease. Therefore, the total engine factor for a configuration can be plotted against its estimate range. Fig. 7 is an example of this for the

five types of power plants selected. Since range is of prime importance in any mission study, one can, aided by a curve like Fig. 7 and knowing the range, pick the best power plant system to use.

The Effect of Adding Drop Tanks

This type of analysis can be used to analyze propulsion system problems other than selection of the engine. For example, the performance of an aircraft is increased by adding drop tanks. Drop tanks are usually added to an aircraft to increase its range. This, in turn, increases its drag and weight which lowers its maximum speed, altitude, and rate of climb.

By using the method of analysis set forth here, a plot of total engine factor vs. range for an engine-airplane configuration with and without drop tanks can be obtained (See Fig. 8). In this analysis allowance was made for the increase in drag due to drop tanks by increasing it in relation to the increase in weight. It can be seen from Fig. 8 that the airplane with tanks has a larger total engine factor at a given range than the airplane without them. This means that if an airplane is designed to carry some of its fuel externally, it will have a greater performance than the aircraft that is not so designed. An aircraft, in order to carry all of its fuel internally and to have the same range, would need a larger frontal area which would result in lower speed, altitude, and rate of climb. An aircraft with drop tanks also has the added advantage of being able to drop its tanks and therefore to reduce its frontal area and to obtain a higher performance aircraft.

This advantage, obtained by adding an external tank, can be compared to the advantage obtained in using a two stage rather than a one stage rocket.

Conclusions

Considering construction of a set of curves, as in Fig. 7, for the power plants for a certain type of mission, one can quickly find the best power plant as a function of the mission range. It can be seen from the curves that lightweight, high-powered engine combinations, like the rocket ramjet and the rocket small turbojet, are superior for high-performance but short-range aircraft. Also, it is apparent that when long range is desired, engines with a low s.f.c., like the turbofan, produce the best overall aircraft. Although the levels of the curves are a function of the rated power of the engine, the slope of the curves is a function of the characteristic of the engine and remains constant. Hence, for power plants with similar value of rated thrust the above relation will result.

An aircraft which carries some of its fuel externally will have a better overall performance than the aircraft which carries all of its fuel internally for the same range. The effect is similar to the increase in performance gained in multistaging missiles.

Sherman M. Fairchild Publication Fund Papers

No.		Member Price	Non-member Price
FF-19	Combustion—An Aeronautical Science—H. W. Emmons, 1958 Minta Martin Aero. Lecture.	$0.75	$1.25
FF-18	On the Main Spray Generated by Planing Surfaces—Daniel Savitsky and John P. Breslin.	0.75	1.25
FF-17	Atomic Reactors (a Symposium).	1.25	1.75
FF-16	Inertial Guidance—W. Wrigley, R. B. Woodbury, and J. Hovorka (revised version of Prep. No. 698).	0.75	1.25
FF-14	Engineering Management Philosophies (a Symposium).	0.50	1.00
FF-12	Transonic Testing Techniques (a Symposium).	1.85	2.50
FF-11	Wetted Area and Center of Pressure of Planing Surfaces at Very Low Speed Coefficients—Experimental Towing Tank, Stevens Institute of Technology.	1.20	1.60
FF-10	Improved Solutions of the Faulkner and Skan Boundary-Layer Equation—A. M. O. Smith.	0.75	1.25
FF-9	A Hydrodynamic Study of the Chines-Dry Planing Body—Experimental Towing Tank, Stevens Instit. of Tech.	1.20	1.60
FF-7	Natural Flight and Related Aeronautics—James L. G. Fitz Patrick.	2.65	3.50
FF-4	Finite Deflections of Curved Sandwich Plates and Sandwich Cylinders—F. K. Teichmann and Chi-Teh Wang.	0.50	0.85
FF-3	The Penetration of a Fluid Surface by a Wedge—Experimental Towing Tank, Stevens Institute of Technology.	1.20	1.60
AHS-1	Helicopter Flight Research at NACA, Langley—Jack P. Reeder.	0.35	0.75
286	Linearized Treatment of Supersonic Flow Through Axi-Symmetric Ducts with Prescribed Wall Contours—Charles E. Mack, Jr., and Ignace I. Kolodner.	0.75	1.25
229	Wave Profile of a Vee-Planing Surface, Including Test Data on a 30° Deadrise Surface—Experimental Towing Tank, Stevens Institute of Technology.	$1.20	$1.60
170	Wave Contours in the Wake of a 10° Deadrise Planing Surface—Experimental Towing Tank, Stevens Institute of Technology.	1.20	1.60
169	The Discontinuous Fluid Flow Past an Immersed Wedge—Experimental Towing Tank, Stevens Institute of Technology.	0.75	1.00
168	Wave Contours in the Wake of a 20° Deadrise Planing Surface—Experimental Towing Tank, Stevens Institute of Technology.	1.20	1.60
167	On the Pressure Distribution for a Wedge Penetrating a Fluid Surface—Experimental Towing Tank, Stevens Institute of Technology.	0.75	1.00
166	An Analysis of the Fluid Flow in the Spray Root and Wake Regions of Flat Planing Surfaces—Experimental Towing Tank, Stevens Institute of Technology.	1.20	1.60
165	Theory and Practice of Sandwich Construction in Aircraft (a Symposium).	1.85	2.50
126	External Sound Levels of Aircraft—R. L. Field, T. M. Edwards, Pell Kangas, and G. L. Pigman.	0.75	1.00
106	Measurement of Ambient Air Temperature in Flight—W. Lavern Howland.	0.35	0.50
104	Tensor Analysis of Aircraft Structural Vibration—Charles E. Mack, Jr.	1.85	2.50
102	Electrical Resistance Strain Gages Applied to Wind-Tunnel Balances—Elmer C. Lundquist.	0.60	0.80
101	Introduction to Shock Wave Theory—J. G. Coffin.	2.65	3.50
100	Blade Pitching Moments of a Two-Bladed Rotor—R. W. Allen.	0.75	1.00

Papers should be ordered by number from: **Special Publications Dept., IAS, Inc., 2 East 64th St., N.Y. 21, N.Y.**

The motions of the planets can serve as a measure of time,
and an accurate clock is thus not always required.
Application of the principles involved is shown to yield useful check points
for the purpose of correcting
inaccuracies inherent in a purely ballistic system.

Celestial Observations for Space Navigation

Lewis Larmore
Lockheed Aircraft Corporation

THE ACCURACY capabilities of pointing and tracking devices have improved over the past few years until the error associated with existing equipment is about 1 sec. of arc. A study by Wilcox* shows that material and temperature limitations will ultimately impose a limiting accuracy of 0.1 sec. of arc. Thus, we may assume that the angular measurement between two celestial objects will be limited to an accuracy of 0.2 sec. or 1 microradian. This value is essentially in agreement with the accuracy predicted by the developers and manufacturers of stellar tracking devices, and their expectations will undoubtedly be realized within the next decade. Navigation in interplanetary space can be aided with the use of an instrument of this accuracy. However, for full utilization of such a device, stellar and planetary observational position corrections will be necessary since the extreme accuracy required gives rise to terms which are usually neglected in any system of earth-bound navigation. Changes of stellar position due to the motions of the stars are insignificant for earth-bound problems, but several stars have proper motion of over 5 microrad. per year. In addition, a coordinate system must be carefully chosen so that its variation is made as small as possible and is still practical.

The absolute accuracy requirement of positional location for mid-course navigation is not well established. Some type of pilotage or radio navigation will undoubtedly be used at the initial and terminal phases of an interplanetary flight, and the purely celestial system is foreseen as being mainly applicable during the mid-course phase. For the basis of computations in this paper, an arbitrary relative accuracy of one part in a thousand will be used—that is, a celestial fix whose estimated accuracy is 1/1,000 of the shortest possible distance between the two bodies will be assumed to be useful. Thus, for a trip from earth to Mars, the required mid-course accuracy requirement will be about 80,000 km. In many cases, more accurate determinations can be made, and the usefulness of the system thereby improved.

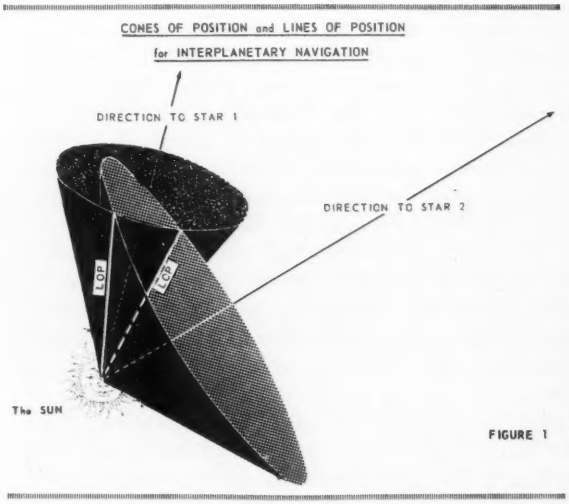


FIGURE 1

Coordinate Systems

When selecting a reference system for use with interplanetary navigation, we come immediately face to face with a problem which has plagued astronomers for hundreds of years. No system of coordinates can be completely free of secular changes because all of our reference bodies are in motion. Thus, in the equatorial system of coordinates used for earth-bound navigation, apparent stellar positions change principally because of the precession of the equinoxes. However, because of its practical significance, the equatorial system continues to prevail and the necessary corrections are computed from year to year. Were we to navigate on the earth's surface with a precision of 1 microrad.

* Wilcox, H., *Interplanetary Navigation Using Celestial References*, presented at the IAS National Summer Meeting, 1958.

This paper was presented at the Space Navigation Session, IAS National Summer Meeting, Los Angeles, Calif., July 8–11, 1958.

Dr. Larmore is Senior Scientific Advisor, Development Planning Department.

TWO-DIMENSIONAL REPRESENTATION OF POSITIONAL LOCI
OBTAINED BY THE ANGULAR MEASUREMENT BETWEEN TWO SOLAR SYSTEM BODIES

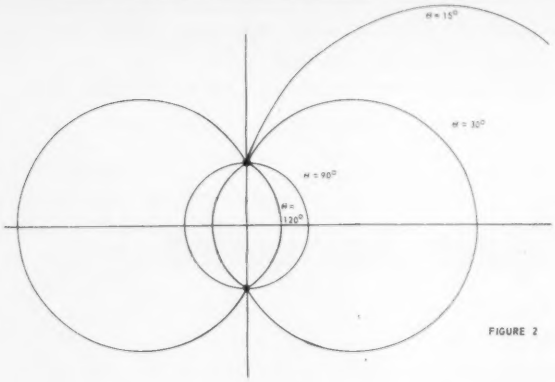


FIGURE 2

(about 21 ft.), the precessional changes of apparent star positions would have to be computed almost daily.

The invariable plane is defined as the plane through the center of mass of the solar system and is oriented so that the angular momentum of the solar system is zero about any axis lying in the plane. Conservation of momentum principles leads us to conclude that the invariable plane would furnish an ideal reference for interplanetary navigation. However, for the practical reasons of observation and residence, the plane of earth's orbit—the ecliptic—furnishes us with a suitable reference. While it is true that the invariable plane is apparently more stable, additional discoveries in the solar system may change the inclination of this reference. For example, the inclination of the invariable plane was shifted 1,200 microrad. with the discovery of Pluto. In making the selection of a heliocentric coordinate system with the ecliptic as the reference plane, we find ourselves in a position somewhat comparable to that of the early English navigators who arbitrarily selected their home base as the zero longitude. The usual definition of celestial latitude—that is, the angular distance north or south of the ecliptic—will suffice for interplanetary navigation. The ecliptic is inclined 1°39′ to the invariable plane and rotates around it in such a manner that the direction of their line of intersection changes by 0.47 sec. of arc per year. Thus, the maximum change in celestial latitude of a star due to this effect is about 0.07 microrad. per year. Corrections to the stellar latitude positions would be necessary at intervals of about 10 years.

In order to determine the azimuth angle or celestial longitude, the current zero point is taken as the first point of Aries. Since this point shifts 250 microrad. per year, corrections to stellar positions in longitude would be necessary almost daily. Thus, a more stable longitude reference point is desirable. The earth's perihelion point has been suggested, but the motion of this point is some 55 microrad. per year. An alternative proposal is one which uses a fairly bright star near the ecliptic for a zero longitude reference. Such a star should be easily recognizable, near the ecliptic, and yet show small proper motion. The first-magnitude star Spica satisfies the conditions, and its motion tangential to the ecliptic is about 0.1 microrad. per year. Corrections of stellar positions due to changes in both celestial latitude or longitude could be made about every 10 years without undue computational labor.

The third coordinate in this system would be the radial distance from the sun's center. Even though the sun travels through space at about 11 miles per sec., interplanetary navigation will not be subjected to this correction since the planets also have this motion superimposed on their own motions around the sun.

Navigation Systems

The most obvious system of celestial navigation in interplanetary space consists of measuring the angle between the sun and another celestial object. For a measurement between the sun and another star, the locus of position becomes a cone with the sun at the apex. An additional sun-star measurement provides a second cone of position, and the intersection of the two cones yields two straight lines of position as illustrated in Fig. 1. Note that this system is exactly analogous to the usual method of earth-bound celestial navigation where the navigator measures the angles between the earth and stars. The intersection of the cone of position with the earth's surface is the usual circle of position, and the intersection of two such circles gives the latitude and longitude of the observer. The ambiguity is removed in both the earth-bound case and the solar case by a knowledge of the observer's approximate position so that the final calculation will be in the form of a correction to an assumed latitude and longitude. One difference in the two systems concerns the matter of time. For the earth-bound case, the observation must be coupled with a time measurement in order to allow for the earth's rotation. However, the celestial latitude and longitude coordinates can be determined without reference to time, and a knowledge of time is important only for a comparison with the predicted orbital position.

Stellar observations will yield only the angular coordinates and not the radial distance from the sun. Addition of a third star observation gives only redundant information, although it would serve to remove the ambiguity of the two lines of position if this is ever a serious matter, and it may improve the accuracy slightly. The radial coordinate can be determined either with a planetary observation or by measuring the apparent angular diameter of the sun. The latter method requires no time standard, but its accuracy depends heavily on the value of the radial distance.

The determination of the radial distance by means of a planetary observation requires the use of time and an ephemeris. A planet-star observation gives a third cone of position which will intersect the line of position shown in Fig. 1 and provide a fix for the vehicle. It is possible to use a planet-sun or planet-planet observation for this same purpose. In this case, the surfaces of position are no longer cones but will assume the configurations shown in Fig. 2 when these curves are rotated

about the line joining the two bodies. Angle θ represents the angle subtended at the vehicle by the two bodies.

The possibility of substituting an additional planetary observation in place of using a clock has been suggested. From a knowledge of the ephemeris of an additional solar system body, time can also be measured. Indeed, an observation of the earth-moon system can serve this purpose, provided the distance from the earth is not too great to allow an accurate measurement of this type. Thus, four observations would serve not only to determine the vehicle's position but also to determine the time of the measurement.

Although many combinations of the above observations are possible, the accuracy discussion which follows is built around the three navigation systems suggested.

(1) (a) Sun-star, (b) Sun-star, (c) Angular diameter of sun.
(2) (a) Sun-star, (b) Sun-star, (c) Planet-star (with time and ephemeris).
(3) (a) Sun-star, (b) Sun-star, (c) Planet-star (with ephemeris only), (d) Planet-star (with ephemeris only).

Uncertainties in Position Due to Instrumental Limitations

An instrument for measuring the angle between two celestial objects will usually be adjusted for pointing at the center of intensity of each object. Thus, whether the image is a sizeable disc or the diffraction pattern of a point source presents no particular obstacle. In accordance with Dr. Wilcox's discussion, we will assume an error of measurement of 10^{-6} rad. The minimum uncertainty in the determination of latitude and longitude will accordingly be 1 microrad. This situation exists only when the angle of intersection of the cones is 90° and when the two tangents of the cones at this intersection are parallel with the latitude and longitude tangents. In all other cases, the error will be greater than 1 microrad. Present navigational practice usually limits the intersection angle to not less than 60° when only two sights are used. This criterion seems to apply equally well to interplanetary navigation. In this case, the uncertainty in longitude or latitude will never be greater than twice the error of the measurement. Fig. 3 illustrates this situation. Transformed into actual linear uncertainty, we must multiply the angular uncertainty by the distance from the sun. Table 1 shows these values for the distances of the planets.

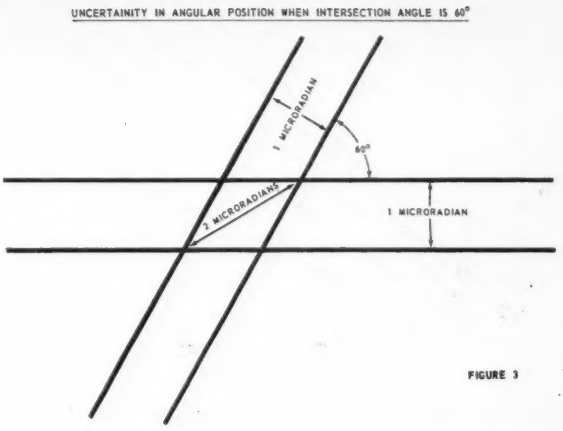


FIGURE 3

A device which measures the angle between two celestial bodies will probably not be suitable for measuring the angular diameter of the sun. A modification or an additional piece of equipment will be necessary for this purpose, but presumably its angular accuracy can still be held to 1 microrad. The uncertainty of position resulting from this measurement is proportional to the square of the distance from the sun and amounts to about 16,000 km. at the earth's orbit. Included in Table 2 is the uncertainty in radial distance from the sun resulting from this method.

As could be anticipated, the uncertainty in radial position is orders of magnitude greater than that in latitude or longitude. However, because of its simple computational requirement, its independence of a time measurement, and its geometrical significance, a radial position determination by this method will undoubtedly find use in interplanetary navigation. In addition, if the 1-microrad. measurement uncertainty represents a Gaussian-type error, smoothing time can be made extremely large, and the possibility exists of decreasing the uncertainties listed.

The accuracy with which the radial distance can be determined by means of a planet-star measurement depends on the distance from the planet and the angle

Table 1
Maximum and Minimum Uncertainty in Latitude and Longitude Positions for Planetary Distances

Planet	Mean Radial Distance, in Km.	Minimum Uncertainty, in Km. (1 microrad.)	Maximum Uncertainty, in Km. (2 microrad.)
Mercury	57,940,000	58	116
Venus	108,270,000	108	216
Earth	149,680,000	150	300
Mars	228,060,000	228	456
Jupiter	778,730,000	779	1,558
Saturn	1,427,700,000	1,428	2,856
Uranus	2,872,400,000	2,872	5,744
Neptune	4,500,800,000	4,501	9,002
Pluto	5,914,800,000	5,915	11,830

Table 2
Uncertainties in the Measurement of Radial Distance, ρ (Based on Planetary Distances From the Sun)

Planets	Uncertainty, in Km. (From Angular Solar Measurements)	Uncertainty, in Km. (From Planet-Star Sight) Intersection Angle = 60°	Planet's Distance From Sun, in Millions of Km.
Mercury	2,400	201	57.9
Venus	11,000	375	108.3
Earth	16,000	520	150.0
Mars	37,000	790	228.0
Jupiter	430,000	2,700	778.7
Saturn	1,450,000	4,950	1,427.7

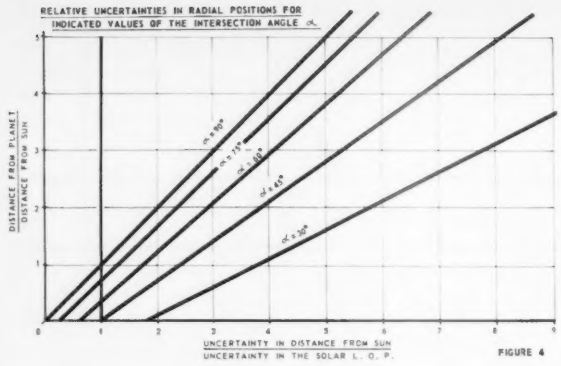

RELATIVE UNCERTAINTIES IN RADIAL POSITIONS FOR INDICATED VALUES OF THE INTERSECTION ANGLE α
DISTANCE FROM PLANET / DISTANCE FROM SUN
UNCERTAINTY IN DISTANCE FROM SUN / UNCERTAINTY IN THE SOLAR L. O. P.
α = 90°
α = 75°
α = 60°
α = 45°
α = 30°

FIGURE 4

of intersection between the conical surface and the line of position from the two sun-star sights. Thus, for minimum error, the planet should be close by and the intersection angle 90°. Since the distance from the sun is determined by the planet-star sight, the uncertainty in this distance will be about equal to the uncertainty in the LOP from the sun-star sights when the planet and the sun are both at equal distances from the vehicle. However, the angle of intersection affects the radial uncertainty to a significant degree. This effect may become serious because of the limited number of planets available for observation. Fig. 4 shows the relative uncertainty as a function of the ratio of the planet distance to the sun's distance for several intersection angles. These straight lines result from the equation $E = (A + \cos \alpha)/\sin \alpha$ where E is the ratio of the uncertainties ($\Delta\rho/\Delta$ LOP), and A is the ratio of the distances (planet/sun). As a practical device, Table 2 includes the results of this second navigational method based on distance of the planets from the sun. Although a comparison of the uncertainties of the second method with the first show that planet-star sights are orders of magnitude superior, there are systematic errors, which will be discussed later, in the second system which tend to reduce the accuracy considerably.

The addition of a second planet-star sight can in principle eliminate the requirement of an accurate chronometer. Indeed, other observations such as occultations and satellite configurations can be used for the same purpose. An error analysis has not been made even for the second planet-star case, but a simple example serves to illustrate the accuracy to be expected. Consider a vehicle between the orbits of earth and Venus as shown in Fig. 5. The latitude and longitude have been established giving a line of position. Earth-star and Mars-star measurements each give a conical surface of position which should intersect the LOP at the same point if the time is accurately known. However, if the chronometer is too fast, the intersection will be as shown in Fig. 6. The surfaces of position obtained from Mars and earth-stellar measurements are approaching each other along the line of position with a velocity of 52 km. per sec. Since there is an uncertainty in their separation distance due to the uncertainty of the measurements, the time of intersection cannot be established positively. In the illustrated example, the uncertainty in their separation distance is 255 km., which divided by their approach velocity gives a possible time error of 5 sec. If we consider an interplanetary expedition of a year's duration, the 5 sec. correspond to about one part in 10^7. Laboratory chronometers are available which provide time standards of five or six orders of magnitude better than this example illustrates. Whether or not these can be successfully put into an interplanetary vehicle remains to be seen, but it appears likely that use of a chronometer will be standard practice for interplanetary navigation.

Systematic Errors

The discussion above has been made on the assumption that the position uncertainty results from only the instrumental limitations, and other possible sources of error have been ignored. The navigational systems based on celestial observations will include some systematic errors. When the values of these errors are known, they can be included in the input of a computer and the necessary corrections made. If the values are not known, the systematic errors must be added to the instrumental error for the final position uncertainty. The following discussion mentions three unknown systematic errors and five which can be corrected.

Size of the Solar System

By far the most important unknown systematic error in interplanetary navigation problems concerns the size of the solar system in terms of laboratory units. While we know the relative values of planetary distances to something like one part in 10^9, we know the distances in kilometers to only one part in 10^4. The best method for obtaining these distances is by triangulation, and somewhere along the way we must use a tape measure, or its sophisticated equivalent, in order to determine the length of a base line. The combination of possible errors in the base line length and the angular measurements leads to a probable error in the astronomical unit of 17,000 km. If we compare this value with the 16,000-km. uncertainty obtained from Table 2 for the navigation system depending on a measurement of the sun's apparent diameter, we see that these are comparable in size. However, these two errors are not independent because the sun's assumed size depends on the assumed size of the solar system. Nevertheless, with our present uncertainty in the astronomical

CONFIGURATION FOR AN ASSUMED NAVIGATION FIX WITHOUT AN ACCURATE CHRONOMETER
(DISTANCES IN MILLIONS OF KILOMETERS)

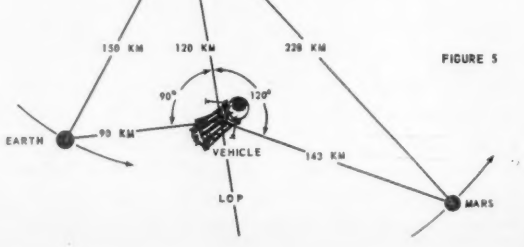


FIGURE 5

unit, the first system of navigation appears to offer a simplicity coupled with an accuracy that is not unreasonable. If our knowledge of the laboratory-standard scale of the solar system is improved, then the second system of navigation will be justified. Early interplanetary flights can and should be used for improving our knowledge of the size of the solar system since this will have a far-reaching effect not only on future interplanetary navigation but also on the improvement of all the astronomical constants involved in the general study of celestial mechanics.

The probable error in the scale of the solar system gives an uncertainty which is linear with the radial distance from the sun, while the possible error from the measurement of this distance by the first navigation system goes as the square of the distance. At the earth's distance, these two uncertainties are about equal. Thus, interplanetary flights inside the earth's orbit using the first system of navigation will have their dominant error resulting from the uncertainty in the scale of the solar system, while flights to Mars and beyond have more uncertainty in the solar angular measurement.

Planetary Positions

In addition to the possible error of planetary positions resulting from the uncertainty in the scale of the solar system, the angular positions of planets are not completely accurate. A part of this error comes from the transformation from geocentric to heliocentric coordinates, but a small amount results from actual observational errors and perturbations. The *American Ephemeris and Nautical Almanac* gives the heliocentric configurations of the planets to 0.1 sec. of arc, which is apparently adequate, but the actual versus predicted positions frequently show errors greater than the 0.2 sec. required by the instrumental accuracy.

Phase of Planets

The instrument for measuring angles between the planets and stars will measure to the center of intensity when the object is not a point source. Planets which are not illuminated at full phase provide a source of error which cannot be completely corrected. For example, Venus subtends an angle of 320 microrad. at closest approach to the earth. Near this time (inferior conjunction) the planet appears as a thin crescent so the error in measurement could amount to about 100 microrad. If we limit the intersection angle between the two sun-star line-of-position and the planet-star surface-of-position to 60°, the error will be substantially reduced since we will observe Venus more nearly full phase. However, it will not be completely predictable because of planetary atmospheres, formation of clouds, and departures from a Lambert law surface. The bulk of the necessary correction can be predicted, but a small unknown residual error will amount to more than the 1-microrad. criterion. Experimental investigation of this problem should be made in the immediate future.

Aberration of Starlight

A star observed from a moving platform suffers an apparent angular displacement which is known as the aberration of starlight. The amount of the angular displacement is given by $\tan \theta = v/c$ where v is the component of the observer's velocity perpendicular to the direction of the star, c is the velocity of light, and θ is the required displacement angle. For an observer on the earth, angle θ can have a value of 102 microrad.—so the contribution of this error is significant. Although this effect leads to the conclusion that we cannot determine our position until we know our velocity, the predicted velocity can be used for a sufficiently accurate correction. Thus, the velocity component perpendicular to the star's direction must be known to 0.3 km. per sec. and the necessary corrections incorporated into the computer.

Parallax of Stars

While we generally assume the stars to be at infinite distance for navigational purposes, this is not strictly true, and the necessary corrections can be determined from their measured parallax. The stellar parallax is the apparent change in direction of a star when observed with a base line equal to the radius of the earth's orbit. Of the 21 first-magnitude stars, seven must have parallax corrections made for navigation within the earth's orbit, and twelve for navigation within the orbit of Jupiter. These corrections can easily be made from a predicted position which requires an estimated positional accuracy of only 8×10^6 km. for the nearest first-magnitude star (α Centauri).

INTERSECTION OF LINE AND SURFACE OF POSITION (INCLUDING THEIR UNCERTAINTIES) FOR THE TWO PLANET-STAR FIX WITHOUT AN ACCURATE CHRONOMETER

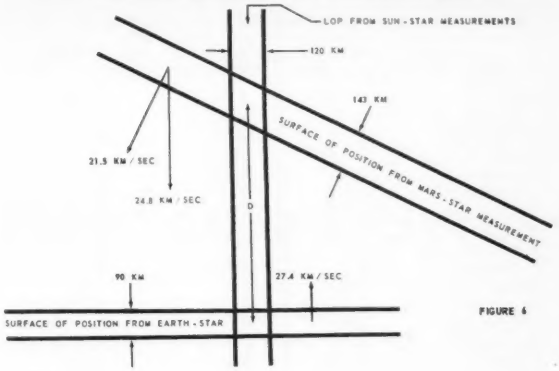


FIGURE 6

Finite Velocity of Light

In addition to the aberration of starlight, the finite velocity of light produces another systematic error which must be corrected. The transit time for light to reach the vehicle from a planet is sufficiently long (for example, 1,000 sec. across the diameter of the earth's orbit) that the planet will have moved by an intolerable amount in the interim. For the example illustrated in Fig. 5, the transit time of light from Mars to the vehicle is 480 sec. Thus, Mars will move over 11,000 km. in this interval. In the same diagram, the light transit time from earth is 300 sec., but the earth moves about 9,000 km. in this interval. These corrections must be fed into the vehicle's computer in order to provide as accurate results as possible. The problem in this case is somewhat more difficult than in the two previous cases since the correction depends on the instantaneous configuration of the solar system, as well as on the estimated position of the vehicle.

Proper Motions of the Stars

The yearly change in direction of stars on the celestial sphere due to the actual motion of the stars is known as proper motion. Values of this motion go as high as 51 microrad. per year, and stellar positions may change significantly even during one interplanetary journey. The 21 first-magnitude stars contain eleven whose proper motions exceed 1 microrad. per year, and the greatest value is 18 microrad. per year for α Centauri. Thus, a positional correction for this star would be required about every 3 weeks. Table 3 lists the 21 first-magnitude stars with their intensity (in magnitudes), parallax, and proper motions. Additional information for fainter stars can be obtained from any one of various astronomical catalogs.

Double Stars

Although the measuring instrument of our navigation system has the capability of determining angles to an accuracy of 1 microrad., it will probably not have the ability to resolve close double stars to this accuracy. It will, therefore, measure to the center of intensity of a double star system. The list of 21 first-magnitude stars includes seven double stars. Of these, two will give errors amounting to over 1 microrad. The star α Crucis is a double with one component 1.6 times as bright as the other and a present separation distance of 20 microrad. Thus, a positional

TABLE 3
First-Magnitude Stars and Their Intensity, Parallax, and Proper Motion

Star	Intensity (Magnitude)	Parallax (Microrad.)	Proper Motion (Microrad./Year)
Sirius	−1.58	1.9	6.6
Canopus	−0.86	0.07	0.11
α Centauri	0.06	3.8	18.4
Vega	0.14	0.6	1.7
Capella	0.21	0.35	2.2
Arcturus	0.24	0.4	11.4
Rigel	0.34	0.03	0.03
Procyon	0.48	1.6	1.6
Achernar	0.60	0.25	0.5
β Centauri	0.86	0.08	0.2
Altair	0.89	1.0	3.3
Betelgense	0.92	0.08	0.16
α Crucis	1.05	0.07	0.24
Aldebaran	1.06	0.3	1.0
Pollux	1.21	0.5	3.1
Spica	1.21	0.07	0.3
Antares	1.22	0.05	0.16
Formalhant	1.29	0.7	1.8
Deneb	1.33	0.03	0.02
Regulus	1.34	0.3	1.22
β Crucis	1.50	0.08	0.27

correction of 8 microrad. must be made if the location of the brighter component is assumed. For α Centauri, the maximum separation of the two components is 88 microrad. and leads to a possible error of 19 microrad.

The two components of a double star system each revolve about a common center of mass. If the mass-luminosity relationship of the stars were linear, the center of intensity would correspond to the center of mass and no problem would exist. However, this correspondence does not hold, and necessary corrections must be determined for use in a navigational system. For α Centauri, the separation distance is currently increasing at the rate of 3 microrad. per year, which indicates that corrections must necessarily be made at approximately yearly intervals.

CONCLUSIONS

Any of the three systems of navigation mentioned give accuracies sufficient for mid-course location, provided we will accept one part in a thousand as the ratio between position accuracy and trip length. The most accurate location method consists of a sun-star pair plus a planet-star sight. Use of this method is not warranted for navigation within the earth's orbit unless we improve our knowledge of the scale of the solar system.

It should be pointed out that the systems of navigation discussed are essentially extensions of our present earth-bound celestial navigation. The possibility of completely new concepts, in which positional measurements need not be made, has been suggested from time to time. For example, Dr. Samuel Herrick, of the University of California, has previously mentioned a system in which the laboratory scale of the solar system is not used and only the relative scale is important. Such a system not only would be of great value for navigational purposes but also could ultimately lead to better measurements of the scale of the solar system. The details of other navigational concepts should be worked out and the errors compared with those of the strictly triangulation methods.

SPECIAL IAS PUBLICATIONS

	Member Price	Nonmember Price
Aeronautical Engineering Index – 1956	$10.00	$15.00*
1955, 1954, 1953, 1952, 1951, 1950, 1949, 1948, 1947 (each)	3.00	5.00*
National Specialists Meeting on Dynamics and Aeroelasticity Proceedings - 1958	3.50	6.00*
Weapons System Management-National Midwestern Meeting Proceedings - 1957	1.50	2.50*
National Naval Aviation Meeting Proceedings - 1957	3.00	5.00*
Second and Third Turbine-Powered Air Transportation Meeting Proceedings (each)	3.50	6.00*
1958 National Telemetering Conference Record	4.00	4.00*
1957, 1956, 1955, and 1954 National Telemetering Conference Record (each)	2.00	2.00*
Fifth International Aeronautical Conference Proceedings	15.00	20.00*
Second International Aeronautical Conference Proceedings	5.00	5.00*
First and Second Convertible Aircraft Congress Proceedings (each)	3.00	5.00*
Index to Books on Selected Technical Subjects in the IAS Library (up to 1950), unbound	2.00	2.00*

*Add $1.00 for orders outside the U.S.A.

These may be obtained by writing to: Special Publications Dept., IAS, 2 E. 64th St., N.Y. 21, N.Y.

1958 National Telemetering Conference Report

Price—$4.00

Special Publications Dept., Institute of the Aeronautical Sciences, Inc., 2 E. 64th St., New York 21, N.Y.

The discussion of a principle which will reduce the incidence of a major failure in ball-bearing suspended gyros.

Achieving Extremely Accurate Nonfloated Gyros

A. W. Lane, M. S. Klemes, and E. L. Zeigler
Sperry Gyroscope Company

THE HISTORY of improvements in gyroscopic instrument accuracy in the last decade or so has hinged mainly on the improvement of gimbal pivot suspensions. A common form of gyroscope consists of a high-speed flywheel spinning in a pair of precision rotor bearings, mounted in a frame or gimbal. The gimbal is, in turn, supported in a pair of "frictionless" pivots, usually high-quality annular ball bearings. The lower the restraint imparted to the gimbal system by the pivots, the lower will be the gyro's threshold of reliable operation. Drift is the term used to designate the gyro's quality and, therefore, its predictability and accuracy.

As it became more evident that ball-bearing supported gyros could not satisfy the ever increasing accuracy requirements, other methods of pivot suspension were applied; among these were air bearings, flotation with low-friction pivot guides, fluid bearings, magnetic suspensions, and several more. In many cases, these new suspensions proved to be a large improvement over the ball bearing, but in every case there was a major increase in the complexity and, subsequently, the cost of the final instrument. Almost every major manufacturer of gyroscopes pursued one or more of these new suspensions, yet there was still hope that the simple, reliable ball-bearing pivot suspension could be improved to meet the needs of the very low-drift gyroscope.

A careful review of ball-bearing characteristics under load will disclose two types of torques; those that dissipate energy and those that are nondissipative. The dissipative torques are caused by friction, be it coulomb or viscous, while the nondissipative torques are produced by energy transfers within the bearing itself or in parts rigidly attached to the bearing races. Some of these nondissipative or conservative torques have been calculated from bearing geometry but could not be measured in a laboratory because they were masked by frictional torques that are several times greater in magnitude.

A bearing manipulation or cyclic motion, called Rotorace bearing, was conceived that would almost exactly average, in a short time period, all of these torques. This new suspension alone caused gyro drift error to be at least 10 times, and probably 100 times, smaller than in a conventional ball-bearing suspension.

Nonconservative Torques and Their Averaging

Nonconservative torques can be subdivided into two classes; namely, torques caused by viscous and coulomb friction. It is well known among gyroscope manufacturers and users that a ball-bearing gyro cannot be tested by setting it down on a bench in the absence of all base motion or vibration and expecting the gyro to meet its specification. The static friction is so high that the drift will be several tens of degrees per hour while the same gyro tested on a Scorsby machine or a table with a small vibration will drift only a few degrees per hour. This implies that all ball-bearing supported gyros require some sort of base motion or dither in order to meet the drift specification.

Fig. 1 illustrates a qualitative frictional torque vs. speed curve for a ball bearing. Starting friction is high but falls rapidly as rotational speed increases to a level which is substantially constant for some range of speed. At higher speeds viscous and dynamic forces cause

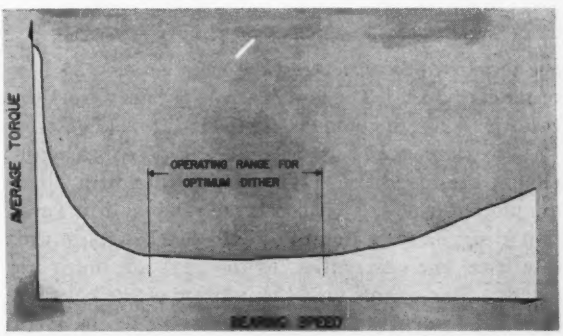
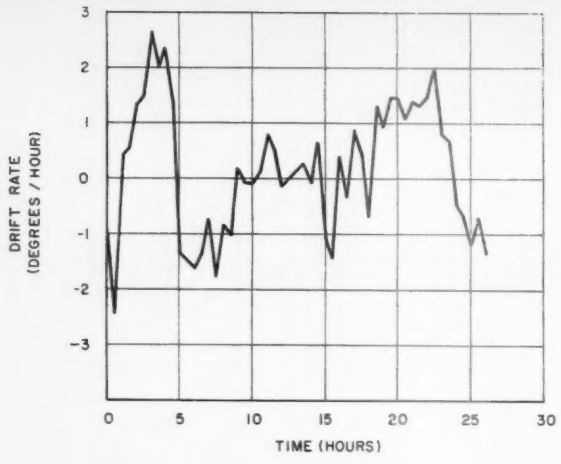


FIG. 1. Average torque characteristic of ball bearing.

Mr. Lane is Department Head, Attitude and Heading Reference Systems, Mr. Klemes—Project Engineer for Development Activity, and Mr. Zeigler—Senior Project Engineer for Development Activity, all in the Aeronautical Equipment Division.



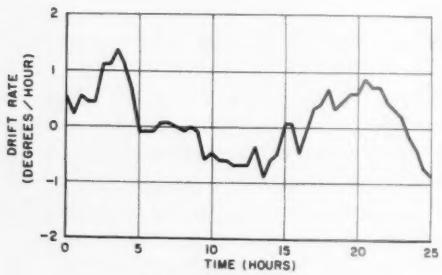


FIG. 2 (*top*). FIG. 3 (*bottom*).

further increases in torque. Some form of base motion or dither is required to avoid the starting and very low speed—high torque level. The curve illustrates average running torque; instantaneous torques are quite erratic, and the torque level varies for a given bearing as a function of bearing temperature, loading, lubrication, cleanliness, etc.

Conventional gyro test specifications allow the use of Scorsby base motion during a gyro test. A Scorsby motion is a sinusoidal motion about 3 axes simultaneously, usually between 1° and 15°, in peak to peak amplitude. This dither, though, is not ideal since the sinusoid allows undesirable dwell periods near zero velocity and, therefore, high static frictional torques. A motion more desirable (optimum dither) would be one that amounted to a constant speed rotation and an instantaneous reversal.

A control test using a production gyro was made on a Scorsby without gimbal bearing dither. The results of this control test indicated that the gyro would pass the required production test specification of ±3°/hour of random drift. The random drift obtained from this test was ±2.5°/hour and is plotted in Fig. 2. Following this 25 hour control test, the gyro was altered to permit gimbal bearing dither. The test results with dither are plotted in Fig. 3. The overall random drift variation is significantly improved and the changes in drift rate from one observation to the next are much less severe. During this test, the position of the balls was observed to slowly wander with respect to the races, and, when the ball assumed a new position, the drift rate usually had assumed a new average value. This perhaps was the first laboratory observation of conservative ball-bearing torques.

Conservative Torques

Conservative torques in a ball bearing may be caused by several factors; first, ball or race imperfections such as pits, dirt, brinnel marks, etc.; second, radial play and the lack of an infinite number of balls. In the first case, imperfections require balls and races to be lifted out of holes and over dirt particles, thus changing the potential energy of the system. The latter case has the same effect but is less obvious and is worthy of a thorough explanation.

To illustrate the conservative torques present in a typical gimbal bearing application, consider Fig. 6 which illustrates schematically a radially loaded ball bearing supporting the horizontal gimbal axis of a gyro. It is apparent that the height of the inner, load-supporting race is a function of the angular position of the ball complement relative to the inner race, and that the load is raised and lowered slightly as the balls pass under the load. The change in potential energy causes a torque, L, to be exerted on the trunnion which is given by

$$L = dU/d\theta$$

the incremental energy change, dU, divided by the increment of rotation, $d\theta$, of the trunnion.

If one assumes further that all parts of a ball bearing are rigid bodies rolling without slippage, it can be shown that a gyro will be subject to drift rates given by

$$\omega_p = (W/H) \times e \times [r/(r + R)] \times \sin \beta$$

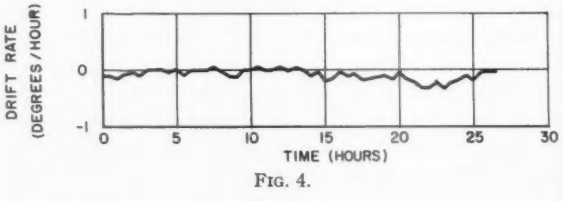


FIG. 4.

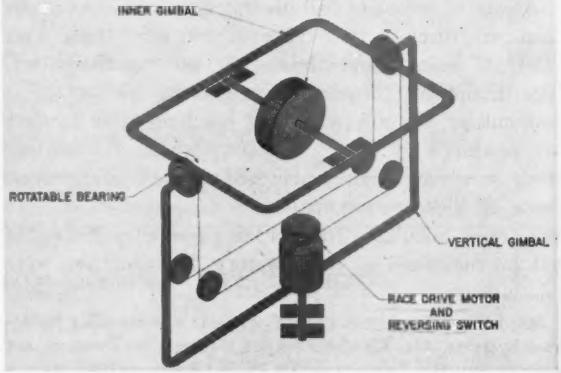


FIG. 5. Rotorace applied to directional gyro.

from the change in potential energy alone. (This equation is derived and the symbols are defined in the Appendix.) The least favorable orientation of the balls in both gimbal bearings of the gyro, mentioned above, would result in a drift rate of 3°/hour.

This effect is present in all ball-bearing suspended gyros. Quantitatively, the drift prediction is not exact because the parts of a ball bearing are not rigid, and various strain energy exchanges are also present. An axially loaded bearing, similarly, is not free from these torques; in practice, an axially loaded bearing often exhibits higher conservative torques than a radially loaded bearing. This is so probably because of wedging of the balls in the ends of the races with increased sensitivity to bearing out-or-round conditions. The calculation is realistically representative, however, of the order of magnitude of torques actually observed. These torques are present whether the bearing is at rest or in any mode of motion.

Torque Averaging Technique

The Rotorace bearing cycle effects theoretically perfect averaging of conservative and nonconservative torques. It can be seen in the Appendix that torques due to ball position are symmetric—that is, for every position causing clockwise torques there is a corresponding position causing counterclockwise torques. Thus, if the bearing is rotated at uniform speed, these torques will integrate to zero. It can be shown that the same result is true for any continuous irregular race profile, such as ellipticity, lack of roundness, etc. All that is required to eliminate conservative torques is a constant-speed rotation of the bearing. On the other hand, a small-amplitude oscillation or dither will not average these torques, since there is not sufficient sampling to provide a good average of the conservative torques.

A ball bearing is also subject to purely random torques resulting from actual dirt particles or from machining imperfections which are equivalent, in effect, to actual dirt. A static or quasi-static bearing may operate for long periods of time under the influence of a particular, randomly located disturbance. Any motion will improve this condition. Statistically, the amplitude of the random disturbances is not affected, but the frequency of occurrence is increased by bearing motion. Such action will average the random torques more quickly and allow less net random wander. From this viewpoint, it is desirable to increase the speed of the Rotorace bearing cycle until other undesirable effects are encountered.

Fig. 5 is a schematic illustration of the Rotorace mechanism, as applied to a directional gyro. This mechanism averages the torques described above as well as all other conservative and nonconservative torques in the ball bearing. In the Rotorace bearing cycle, essentially conventional gimbal bearings are rotated at an appropriate constant speed for several revolutions, the direction of rotation being reversed periodically. Where the pair of bearings is used, the bearings

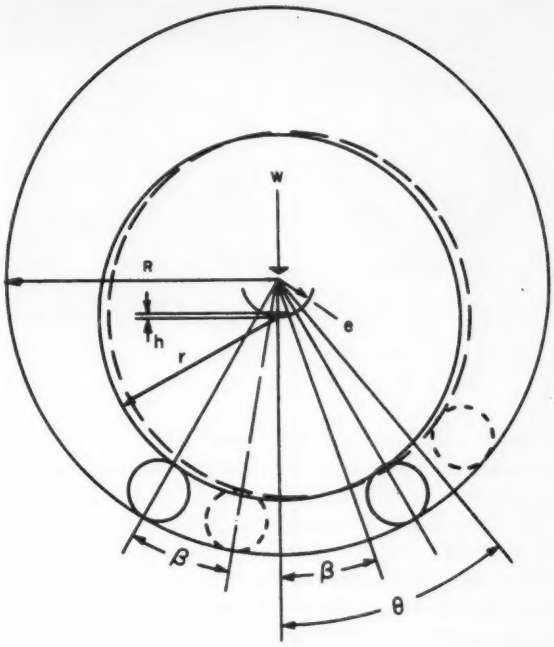


Fig. 6.
θ, angular position of inner race.
β, angular position of balls.
e, no-load eccentricity of races.
h, height of inner race above low point.

are rotated in opposite directions to cancel the drag of a constantly rotating bearing.

The gyro previously used to perform the dither tests was modified to accommodate the Rotorace bearing cycle. Several long drift tests were run with the Rotorace bearing motion. The results were ten times better than the results of the control run. For over 100 hours of continuous test and 100 hours of short tests the drift rate was ±0.25°/hour. During this entire test period no calibration adjustments were made on the gyro. Fig. 4 illustrates a portion of these tests.

It remained to determine how much of the remaining 0.25°/hour random drift variation was caused by the residual bearing torques and how much was contributed by the mass instability and electrical coercion torques inherent in this gyro design. It was assumed that the bearing rotational speed and period of reversal, chosen mainly for convenience, would not be optimum; therefore, an evaluation of a wide range of these parameters was undertaken. It soon became obvious that these parameters had little effect upon the remaining random drift variation of this gyro.

The gimbal bearings being rotated in the model were among the finest ball bearings available. Their tolerances and workmanship could not easily be surpassed. Perhaps, then, their residual torques were being masked by torques not assignable to the bearings. In order to substantiate this, less precise bearings of ordinary commercial grade and appropriate size were obtained. These bearings came lubricated with grease, whereas gimbal bearings are lubricated only with a few

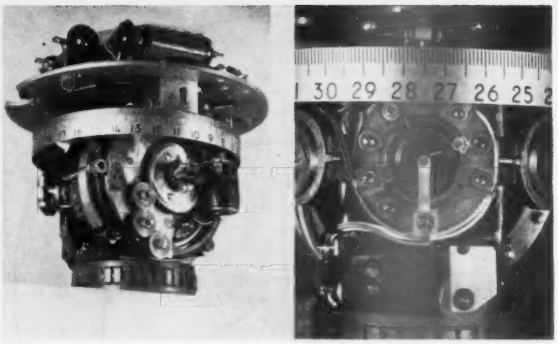


FIG. 7. Rotorace applied to type C-11 directional gyro.

drops of very fine oil. The static breakaway torque of these bearings was so high that a precision gimbal-bearing torque tester was not able to rotate them. These bearings were assembled into the gyro as they were received and the drift tests resumed. The lower quality bearings caused little change in the random drift performance of the gyro, thus indicating that the Rotorace bearing cycle does effectively average bearing torques to a very low level.

To date all attempts to tie down the exact residual torque in Rotorace bearings have not been completely successful, but under exceptionally well-controlled laboratory test conditions Rotorace gyros have exhibited random drift rates as low as 0.05°/hour. For the gyro tested, this drift rate could be caused by a 1 dyne-cm. torque. It is safe to conclude that the residual torque in the Rotorace bearings is no greater than 1 dyne-cm., whereas the same bearings, in a standard configuration with Scorsby motion, exhibit about 50 dyne-cm. torque.

The Rotorace principle has been applied to the directional gyro of the Type C-11 Gyroscyn® Compass System which is now in production. This gyro (Fig. 7) exhibits 0.5°/hour random drift in normal aircraft environments. The addition of the Rotorace mechanism added less than 1/2 lb., required no additional volume, and only moderately increased the cost of the gyro over its predecessor.

The incorporation of a Rotorace gimbal suspension in a new, fully maneuverable, three axis, twin gyro, gyroscopic reference system has materially contributed to its ruggedness and simplicity coupled with notably low gyro drift rates. The azimuth axis exhibits reliable drift rates less than 0.25° hour while the roll and pitch free drift rates are less than 2°/hour. An important features of these gyros is that their performance stabilizes only minutes after they are turned on with practically no change from turn-on to turn-on.

CONCLUSIONS

The Rotorace bearing principle is a method of activating a gyro gimbal bearing in such a manner that the average torque level of the bearing is reduced by a factor of at least 10. This principle, in addition, will reduce the incidence of one of the major failures in ball-bearing suspended gyros, namely, deterioration of gyro performance due to contamination or brinneling in the gimbal bearings. The numerous advantages of Rotorace bearing system make it a very attractive gyro suspension and permits ball-bearing suspended gyros to fulfill requirements heretofore reserved for more exotic designs.

APPENDIX—DERIVATION OF CONSERVATIVE BEARING TORQUE EQUATION

Fig. 6 shows a radially loaded bearing supporting a weight, W. The elevation, h, of the inner race is some function of the angular position, θ, of the inner race related to the balls. It is assumed that the inner race is supporting and is stabilized by a gyro of angular momentum, H, and will not rotate because of torques about the bearing axis. If a virtual displacement of the inner race is considered, the potential energy change must equal the work done against axial torques. Thus,

$$Wdh = Ld\theta \tag{1}$$

where L is the resulting torque. The gyro will precess in accordance with

$$\omega_p = L/H \tag{2}$$

where ω_p is the gyro precession rate and H is the angular momentum of the gyro. The precession rate can then be represented by

$$\omega_p = (W/H) \times (dh/d\theta) \tag{3}$$

The elevation h can be shown to be equal to

$$h = e(1 - \cos \beta) \tag{4}$$

where e is 1/2 the no load radial play in the bearing and β is the ball position angle which is considered equal to zero when two balls are symmetrically spaced about a vertical center line. The relation between the rotation of the balls and the inner race can be given by

$$\theta = [(r + R)/r]\beta \tag{5}$$

where θ is the angle through which the inner race would have to be rotated to make β equal to zero. R is the radius of the outer race and r is the radius of the inner race.

Differentiating Eqs. (4) and (5) with respect to β and substituting into Eq. (3) produces

$$\omega_p = (W/H)[r/(r + R)]e \sin \beta \tag{6}$$

"In the most critical stages of VTOL take-off and landing, at near zero airspeed, when lift is instantaneously destroyed by engine malfunction, conventional escape systems do not work. To bridge this gap in operations capability, a new type of parachute opening device was conceived."

Extending Capabilities of Escape and Aerial Delivery Systems

Fred B. Stencel

Stencel Aero Engineering Corporation

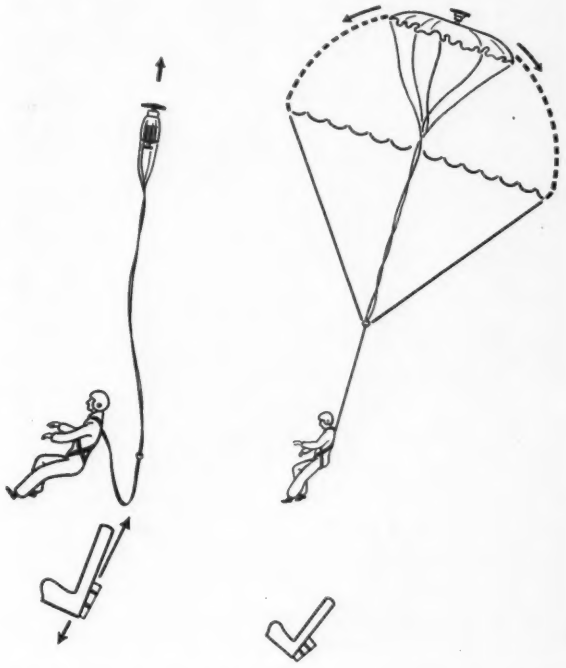


FIG. 1. Phase 1: pack projection; phase 2: canopy spreading

WITH THE ADVENT of VTOL aircraft types which in hovering rely entirely on engine performance, a new requirement for a parachute recovery system has arisen.

A conventional parachute is deployed by the action of airflow which, transmitting power to a pilot chute, pulls the folded parachute out of a container whereupon dynamic pressure unfurls and inflates the canopy. In hovering flight, when airspeed and kinetic energy potential is close to zero, this deployment system becomes inoperative unless sufficient airspeed is first gained in free fall to obtain power for the development sequence. Consequently, the minimum altitude for conventional recovery from zero speed condition is about 200 ft. If an ejection seat is employed, benefit is derived from the apogee height of the seat trajectory. In VTOL of the tail-sitter type which hovers with its longitudinal axis in a vertical attitude, seat ejection would occur substantially in a horizontal plane and would not contribute to gaining altitude.

In the most critical stages of VTOL take-off and landing, at near zero airspeed, when lift is instantaneously destroyed by engine malfunction, conventional escape systems do not work.

To bridge this gap in operational capability, a new type of parachute opening power device was conceived, its feasibility tested, and subsequently developed under sponsorship of U.S. Army and Air Force. In its immediate application the escape system was tailored to the specific requirements of individual lift devices. During development sufficient experience has been gained to evaluate the potentiality of this new engineering tool for a number of other applications.

The author is Vice-President and Chief Engineer. The development discussed in this article was recently demonstrated before IAS and AHS members. A report of this event may be found in this issue's IAS News—Washington Section (p. 112).

OPERATION PRINCIPLE OF THE DIP PARACHUTE

For convenient reference, the term DIP (Deployment effected by a self-contained Internal Power source) is used.

As depicted in Fig. 1 on a seat-type parachute application, the DIP system operates in two distinctive phases. Pack projection (phase 1) is shown at left; canopy spreading, (phase 2) at right.

In phase 1, the canopy, firmly packed in a deployment bag, forms a parachute pack (Fig. 2) which is projected upward by a cartridge-actuated device. During its travel, the suspension lines deploy from retaining pockets until the lines are nearly stretched. In this position the movement of the pack is arrested by a set of snubbing lines which are attached to the bottom of the deployment bag.

In phase 2 the deceleration releases a firing pin which ignites a cartridge contained in an ejection gun This gun has a number of radially spaced barrels in which small projectiles are placed. Each projectile is connected to the skirt of the canopy. The projectiles,

FIG. 2. Parachute pack.

radially ejected, impart their momentum to the canopy skirt and subsequent canopy portions, thus pulling the canopy folds out of the deployment bag. The length of the suspension lines determines the radius of a circular path along which the projectiles are forced to move.

Assisted by centrifugal acceleration, the canopy assumes the approximate shape of a fully opened parachute.

A motion analysis of the canopy spreading phase is shown in Table 1. The canopy, packed in its deployment bag, was placed on a supporting surface in an upside down position; the suspension lines were extended upward and their ends tied to a firm support. Thus, any drop velocity was eliminated and no inflation assistance derived. Evaluation of the sequence shows that the diameter corresponding to the fully inflated canopy shape was reached after 0.167 sec.

The complete operation cycle of the system is shown in Table 2, including data for drop distance and rate of descent at time intervals. In this test, drop release and parachute actuation were simultaneous.

The equilibrium rate of descent for the parachute with the employed load and at the observed atmospheric conditions is approximately 28 ft. per sec. Table 2 shows that at no time within the entire drop distance of 44 ft. was this rate of descent reached. At zero airspeed, with no time lag between commencement of free fall and parachute actuation, safe recovery from any distance above ground is obtained.

OPERATIONAL VARIABLES

At higher speeds, deployment of this parachute occurs under conditions not encountered in conventional parachute applications. The effect of "apparent mass" becomes a governing factor. The term "apparent" or "virtual mass" denotes the mass of air entrapped by the enveloping canopy, modified by a number of factors derived from unsteady and steady flow phenomena, and associated with cloth geometry and porosity.

The condition accentuating the apparent mass effect stems from the peculiarity that the parachute is already inflated while still in a crosswise position to the path of the moving object. Table 3 shows a motion analysis taken from a live test. The subject standing on a boat moving with 25 m.p.h. velocity, fired the parachute, the projection gun being fixed to the boat. Since inflation occurs long before the parachute is in a trailing position, a pendulum effect incurs between the moving mass of the man and the still mass of air entrapped in the canopy. Through acceleration interaction between the masses, the man is pulled up by a vertical force component. The rotation superimposed on translation may at higher speeds produce an undesired amount of angular displacement.

There are several ways available to check rotation. Projecting the parachute backwards eliminates the

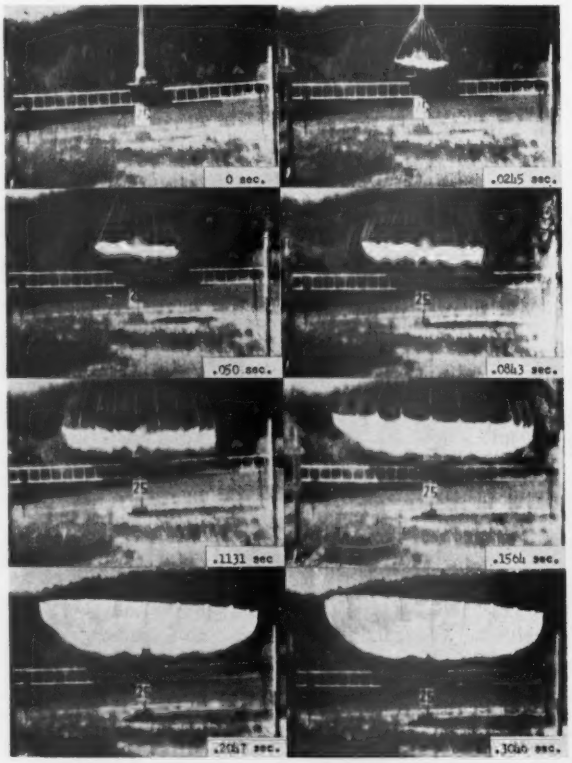


Table 1. Motion analysis of canopy spreading phase.

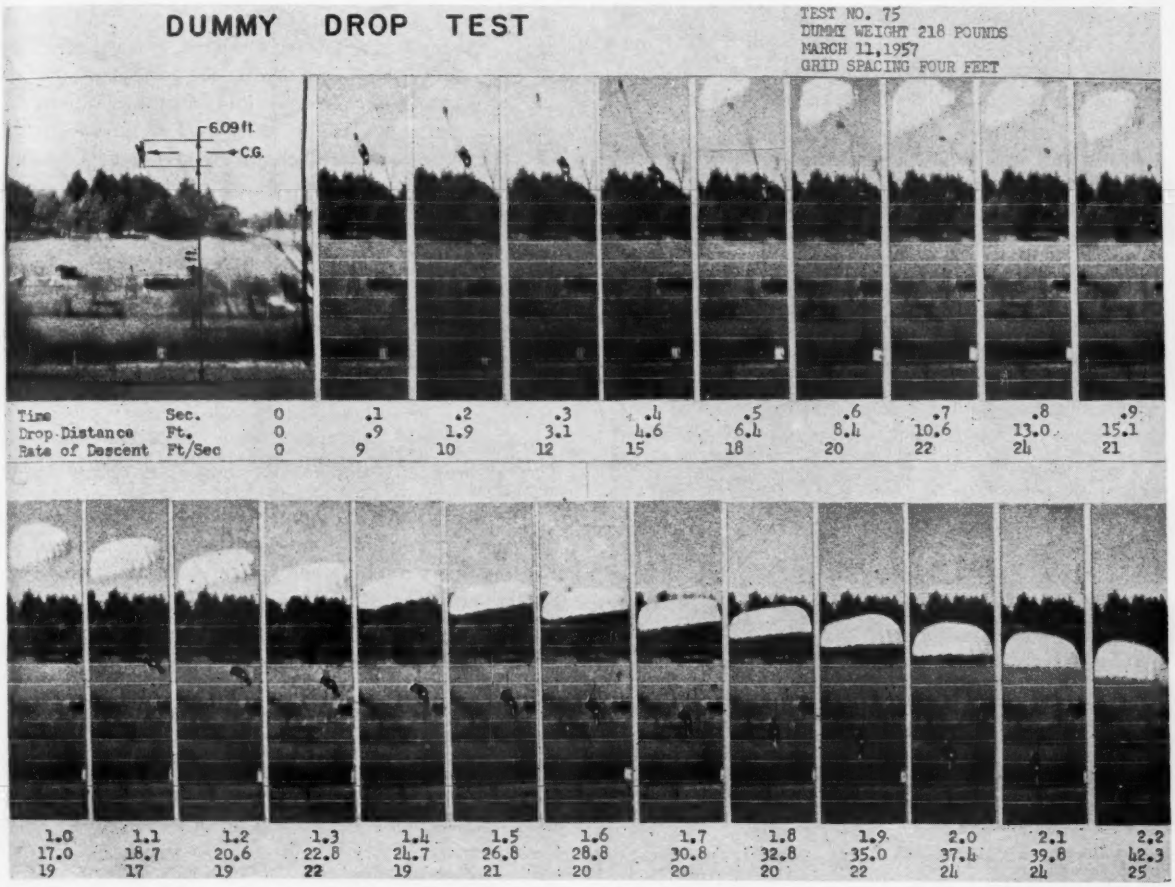


Table 2. Operation cycle analysis of XMP-2, Back Style.

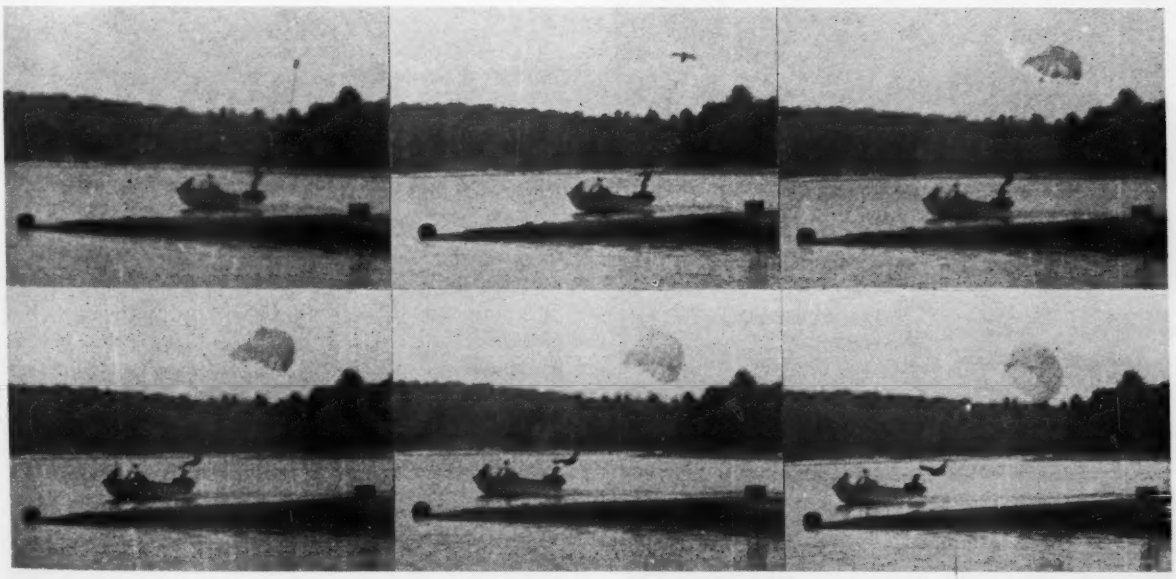


Table 3. Escape from the speed boat.

pendulum effect; however, an excessive opening shock will result at higher velocities.

A very satisfactory way to check pendulum motion is presented by the motion analysis series of Table 4. The procedure employed allows the canopy to deflate before swinging back to the trailing position. Table 4 contains two test series under equal conditions of load, projection angle, and velocity of 80 m.p.h. The difference in deployment is achieved by design variables which, in one configuration, cause the canopy disk to deploy under a positive angle of attack, and in the other, under a negative angle. Inflation, assisted through a positive angle of attack, results in a high apparent-mass and pendulum effect, while a negative angle causes momentary deflation of the canopy. The canopy, assisted by the ejector gun mass at the apex, stretches out, swings back to trailing position, and reopens conventionally, similarly to the deployment process encountered when a static line is used. A negative angle of attack was obtained through a low release setting for the inertia actuator firing device, thus utilizing the "sail effect" of the suspension lines by which effect the pack is tilted forward. Using this type of angle control, the negative angle increases with increasing forward velocity. In this way, a positive angle of attack, harmless or beneficial at low velocities, changes progressively to a negative angle with increasing speed. This self-adjusting feature successfully checks the pendulum effect stemming from excessive

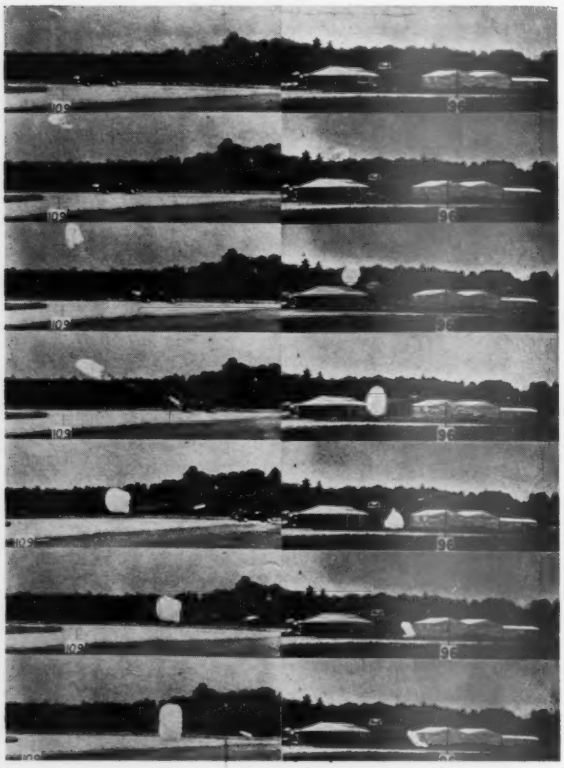


Table 4. Motion analysis comparing parachute deployment at a negative and positive disc angle of attack.

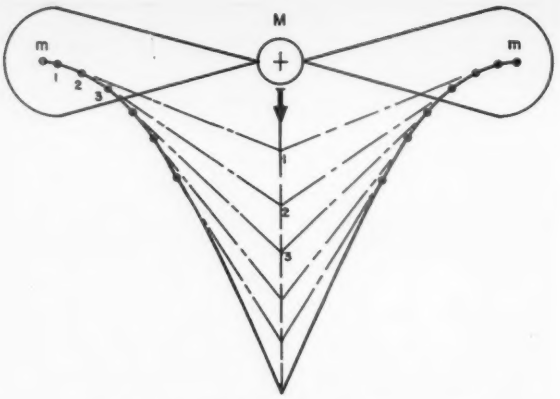


FIG. 3. Symmetrical parachute arrangement.

apparent mass momentum, yet assures full efficiency at zero speed.

Another way of checking pendulum motion consists of using a symmetrical mass arrangement. Instead of ejecting one parachute across the airstream, two parachutes are ejected in opposite directions. This is depicted in Fig. 3.

Furthermore, the apparent mass of two parachutes is less than the apparent mass of one equally effective parachute. This is due to the fact that the area of the parachute increases with the square of its diameter, whereas the volume of the hemisphere formed by the inflated canopy is a function of the cube of the diameter. The symmetrical arrangement is also feasible for zero-speed recovery, as the initial free-fall acceleration of the recovered mass is decreased by the inertia of the two apparent masses, which, at the beginning of free fall, have to be laterally accelerated to follow the recovered mass. For optimization, this system can be combined with angle of attack control.

PRESENT AND FUTURE APPLICATIONS

Individual Lift Devices

Complying with immediate military requirements, the application engineering was directed toward the adoption of the DIP system to emergency personnel recovery from Individual Lift Devices. Two parachute models, XMP-2, Parachute Personnel, were developed: one, the Ultra Fast Opening Back Style, UFOP; the other, the Platform Mounted UFOP. (Figs. 4 and 5). For both the Back-Style UFOP in Fig. 4 and the Platform-Mounted UFOP in Fig. 5, a 24-ft. circular flat canopy is used. The slugs, attached to the canopy skirt, weigh a total of 3 lbs. The deployment devices add another 4.5 lbs. Recoil force peak of the Back Style UFOP is 1,300 lbs., delivering an impulse of 30 lb. sec. No grave discomfort was felt by the subject after six consecutive projections from his back. Therefore, no recoil-less type of projection was deemed necessary although it would be readily available.

The XMP-2 types of DIP parachutes were developed to the specific and limited requirements of emergency

escape from Individual Lift Devices. The operation of the XMP-2 requires that projection take place in a direction substantially crosswise to the flight direction, though tolerating as much as a ±60° deviation. Within the operational limits of Individual Lift Devices, no special steps had to be taken to assure attitude control. In a general application, involving unstable loads and higher velocities, attitude control of the recovered body prior to parachute projection becomes a prerequisite.

Ejection Seats

In applying the DIP parachute to ejection seats, the indispensable condition of seat stabilization is already an accepted feature and does not involve major problems. The use of oppositely and laterally projected twin parachutes (Fig. 3) offers advantages. It promises effective recovery from all conventional aircraft and VTOL take-off in a vertical, nose-up attitude; it prevents interference with a stabilization or descent parachute, and is generally beneficial in decreasing opening shocks. Available general parachute experience implies that no difficulties are expected, if the release speed does not greatly exceed 300 knots. An ejection seat recovery system employing a stabilizing parachute, a descent parachute possibly doubling as a deceleration chute, and the main DIP twin unit is available in its concept stage. The capability of this system extends through the complete operation range from zero altitude and zero airspeed through conventional take-off or VTOL transition to 600 knots at 100 ft. above the ground and to supersonic speeds at higher altitudes. It provides an effective escape from aircraft standing still on the ground in emergency cases involving fire and is universally adaptable to conventional aircraft and VTOL aircraft employing both horizontal and vertical ground contact attitudes.

FIG. 4. Back Style UFOP.

FIG. 5. Platform Mounted UFOP.

Aerial Delivery

Although no zero-speed capability is required for present aerial delivery systems, the precise, split-second timing of the DIP parachute opens up new avenues for improved aerial delivery systems. The advantage of precision timing gains in importance with increasing parachute sizes. Opening times for parachutes involving sizes to 200 ft. diameter vary as much as 20 sec. The target dispersion of equipment dropped at high wind conditions is a penalty stemming from variable opening altitudes affected by erratic opening timing.

Present-day aerial delivery, due to unrealiability of opening time, is limited to a certain flight altitude envelope. At higher altitudes drift becomes excessive,

at lower altitudes some of the parachutes may not open. In the intermediate useful altitude range carrier aircraft is extremely vulnerable from prevalent antiaircraft fire. Therefore, a definite requirement exists to drop loads and troops either from extremely low altitudes allowing contour shielded hedge-hopping approach techniques, or else, from very high altitudes, out of common antiaircraft range.

The advantage of ultrafast and precision-timed parachute opening for near ground-level altitudes is obvious. Aerial delivery techniques from high altitudes require that the load descend at the highest practicable rate. Thus, the time during which the dropped load is affected by wind drift is shortened, and delivery precision enhanced. This high rate of descent has to be broken prior to ground impact by deploying a parachute of proper size at the last possible moment. This deployment can be either pretimed or controlled by a ground-sensing device. In either case, a positively controlled, split-second timed canopy deployment will result in a maximum system performance.

Paratroop Reserve Parachute

In addition to the main parachute, a paratrooper is equipped with a reserve chest parachute. At partial failures resulting in a rate of descent of around 35 ft. per sec., the relative airspeed is not sufficient to deploy the reserve parachute reliably, yet this rate is critical to the paratrooper on ground impact.

An opposed firing chest-type DIP twin unit does not have a critical rate of descent and assures immediate positive opening. Its usefulness can be extended to a standard procedure; by actuating it a few feet before landing, in addition to the main parachute, the ground impact can be considerably decreased. Generally, new avenues for multistage techniques are available.

High Altitude Applications

The DIP parachute allows canopy deployment in a complete vacuum. A parachute designed for a rate of descent of 25 ft. per sec. at sea level requires for its deployment an airflow of twice that speed. In order to produce minimum deployment forces, high supersonic speed is required at 200,000 ft. altitude; above 300,000 ft., hypersonic speed is necessary. Although the aerodynamic forces are very small, considerable heating occurs. In cases involving steep trajectories, where the speed of the body at trajectory peak is relatively low, it can be advisable to fully deploy a parachute at the earliest possible moment in order to prevent unnecessary aerodynamic heating. Rocket sondes, probing the fringes of the atmosphere, might well benefit from the early deployment capability of a power assisted parachute. Associated with this application is also the free-fall distance the body has to travel to obtain parachute deployment speed. At sea level a free falling body requires the minimum speed of about 50 ft. per sec. through a vertical distance of only 40 ft. At a 200,000 ft. altitude level the body has to fall through a distance of as much as 18,000 ft. to encounter minimum deployment forces. Since at extreme altitude levels the opening of conventional parachutes always occurs at supersonic speed, it is important to find means to eliminate the violent cloth oscillation which has been observed during parachute inflation in the supersonic region, and which has been ascribed to shock-wave action induced by the cone of suspension lines preceding the canopy. A positive and forceful canopy spreading might prove beneficial in order to pass a critical opening diameter quickly.

Conclusions

By adding a self-contained power source to the conventional parachute canopy, its deployment process has been made greatly independent of airflow conditions. A number of improvements to parachute applications have become accessible, extending to zero-speed opening capability, ultrafast and precision timed action, new cross-stream deployment techniques utilizing "apparent mass" effect, and high-altitude recovery methods.

✦ ✦ ✦

New Publication Now Available

The Proceedings of the National Specialists Meeting on Dynamics and Aeroelasticity (November 6, 7, 1958) contains all **unclassified** papers presented at the meeting.

Member Price: $3.50 **Nonmember Price: $6.00**

Special Publications Department
Institute of the Aeronautical Sciences, Inc.
2 East 64th Street, New York 21, N.Y.

"The greatest danger of collision or near miss results from encounters between pairs of aircraft wherein at least one of the pair is in VFR flight."

The Occurrence and Avoidance of Midair Collisions

Seymour J. Deitchman
Cornell Aeronautical Laboratory, Inc.

DESPITE the considerable amount of work devoted in recent years to the development of devices and systems for avoiding midair collisions, many questions reaching beyond considerations of hardware development continue to plague those seeking solutions to the problem. For example:

(1) Can collision avoidance best be accomplished through airborne hardware or through air traffic control?

(2) Will proximity warning alone help to avoid collisions?

(3) Should an airborne collision avoidance system be cooperative or self-contained?

These questions cannot be answered precisely because there are conditions under which any of the possible answers may be valid, and others under which they may not be applicable. Therefore, to delineate the relative value of the various approaches to collision avoidance, the physical or engineering requirements for averting midair collisions must be combined with knowledge of the nature of air traffic and the circumstances under which collisions occur.

An analysis of this kind has been performed at the Cornell Aeronautical Laboratory, Inc. The data resulting from the aviation activity forecasts performed for E. P. Curtis[2–5] were applied to the construction of a simple air traffic model. The model was examined to obtain a description of the air traffic environment, the nature of the midair collision hazard, and an evaluation of the utility of various airborne devices or systems for collision avoidance.

Physical Requirements for Collision Avoidance

It will be useful first to describe the physical conditions necessary to anticipate and avoid a midair collision. They will be presented here without derivation.[1]

Much of the work described in this paper was performed at the Cornell Aeronautical Laboratory, Inc., under the sponsorship of the Bendix Aviation Corporation, Detroit, Mich., and was reported in reference 1.

Mr. Deitchman is Section Head, Systems Synthesis Department.

Evasive Action

Evasive action may be taken through maneuvers, or combinations of maneuvers, which change altitude through a pull-up or push-over, displace the aircraft laterally through a turn, or cause the aircraft to change its longitudinal approach to the collision point through acceleration or deceleration. For collision avoidance maneuvers to be acceptable as a routine matter, particularly with passenger-carrying aircraft, the avoidance maneuvers should be gentle.

Let the desired minimum displacements s_m be 500 ft. vertically or 1/4 mile laterally, where s_m is the closest approach to the collision point, measured along the radius of flight path curvature; and let the acceleration component, above 1g, in the plane of symmetry and perpendicular to the longitudinal axis of the aircraft be limited to 0.1g. The maneuver time for a vertical displacement will be

$$t_m = \sqrt{(s_m{}^2/V^2) + (2s_m/a_n)}$$

where a_n is the normal acceleration V^2/R, R is the flight path radius, and V is the (constant) aircraft velocity. The corresponding time for a turn is

$$t_m = \sqrt{s_m(s_m + 2R)}/V$$

where R is the turn radius $V^2/g \tan \phi$ and ϕ is the bank angle. In either case, t_m is found to be relatively independent of velocity. The time for a vertical displacement of 500 ft. with 0.1g normal acceleration increment is approximately 18 sec.; the aircraft will require a 12° bank angle to displace 1/4 mile laterally in the same time, and the normal acceleration increment (perpendicular to the seat) will be less than 0.1g.

Acceleration or deceleration along the aircraft flight axis will require much longer time than this. For example, to arrive at a point 1/4 mile short of the collision point in 18 sec., the aircraft would have to decelerate at about 0.25g, starting at the initial detection point discussed later. However, except for military aircraft at extremely high speeds, aircraft will rarely achieve even half this value.[4] Thus, the vertical maneuvers or turns may be considered the recommended avoidance maneuvers.

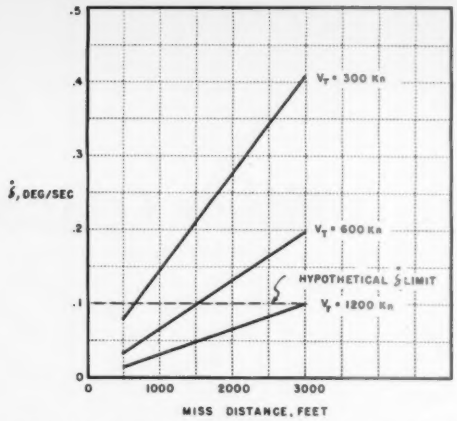


FIG. 1. $\dot{\delta}$ in a head-on approach 30 sec. before passing.

In addition to the maneuver time, there will be a maneuver lag composed of pilot reaction time and aircraft response time. This time will be variable but probably not over 6 sec.[1] for any aircraft if the pilot reaction time is less than 1 or 2 sec.—i.e., if he knows what to do, after the situation has been evaluated.

Threat Evaluation

If both aircraft remain in steady rectilinear flight, the necessary and sufficient conditions for collision to occur are

$$\dot{\delta} = 0$$

$$\dot{s} < 0$$

or

$$\dot{s} = \text{constant} < 0$$

where

$\dot{\delta}$ = bearing angle (angle between the direction of motion of the observing aircraft and the line-of-sight from it to the observed aircraft)
s = distance between the aircraft
$\dot{s} < 0$ assures that the aircraft are not on parallel or separating courses

Since these conditions must be tested in a short time over distances where, in a near-miss situation, $\dot{s}$ and $\dot{\delta}$ change little with time, extremely serious demands, which have not yet been met,[6] are made on the accuracy of detection and evaluation equipment. For example, if two aircraft were approaching head-on at a closure rate of 2,400 knots, δ would have to be measurable within approximately 12 min. of arc, or $\dot{s}$ within 0.1 ft./sec., for successful evasive maneuvers of the kind described above.[1] Now the miss distance achieved must include the desired displacement, as well as that due to the uncertainty of measurement of $\dot{s}$ or $\dot{\delta}$, so that the miss distance must increase as the measurement precision decreases. Then either the avoidance maneuvers must be more violent if the detection ranges (described below) are not changed, or the detection ranges must increase if the maneuvers are not changed.

The accuracy requirements will decrease as the closure rate decreases. Fig. 1 shows that, if a hypothetical limit of accuracy on $\dot{\delta}$ evaluation is 0.1 deg./sec., then a miss distance of at least 700 ft. is required to assure collision avoidance in a head-on approach with a closure rate of 300 knots, but at least 3,000 ft. are needed if the closure rate is 1,200 knots. Thus, it may be found possible, within the limits of available equipment, to avoid low-speed but not high-speed collisions.

Threat Detection

The range s_D from the observing aircraft at which the threat must be detected is given by

$$s_D^2 = (V_B t_c)^2 - (V_A t_c)^2 + 2(V_A t_c) s_D \cos \delta$$

where

V_A = (constant) speed of the observing aircraft
V_B = (constant) speed of the threat aircraft
t_c = time available to detect and evaluate the threat and accomplish the displacement s_m

This is the equation of a circle whose radius, for a fixed value of t_c, depends on V_B and whose center moves along the line of flight of the observing aircraft as V_A varies. The envelope of horizontal detection ranges needed to protect the observing aircraft against threats throughout its speed range up to a given maximum speed is shown in Fig. 2, which also shows the vertical detection envelope needed to protect against aircraft changing altitude.

If it is assumed that detection and evaluation of the threat will require 5 sec., then the total time for avoidance with the maneuvers described previously will be 29 sec.* The required forward, side, and aft detection ranges under these conditions are shown in Fig. 3. The detection ranges in Fig. 3 assume perfect accuracy in the means of detection and evaluation of the threat. Figs. 4 and 5 show the effect of reduced system accuracy on detection range and evasive maneuvers, respectively.

Nature of the Collision Hazard

Although air traffic flow and structure have been measured in some detail in recent years,[2] the results of these measurements are difficult to apply to analysis of the collision problem because altitude data, particularly for VFR aircraft, are generally missing from the statistics. The probable altitudes of individual aircraft in the traffic complex can be estimated from knowledge of their performance characteristics. It is a short step from assignment of altitudes to construction of a model simulating air traffic; the use of a traffic model, based

* This time could perhaps be reduced considerably through increasing the severity of the avoidance maneuver beyond 0.1g. However, the assumption of 5 sec. for detection and evaluation is optimistic so that, in practice, reduction of maneuver time will be compensated by an increase of detection and decision time; 29 sec. approximates the minimum acceptable time for collision avoidance.[6]

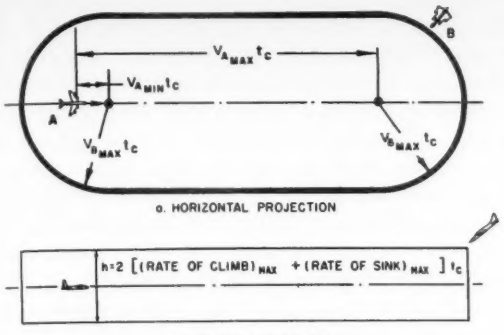


FIG. 2. Detection envelope.

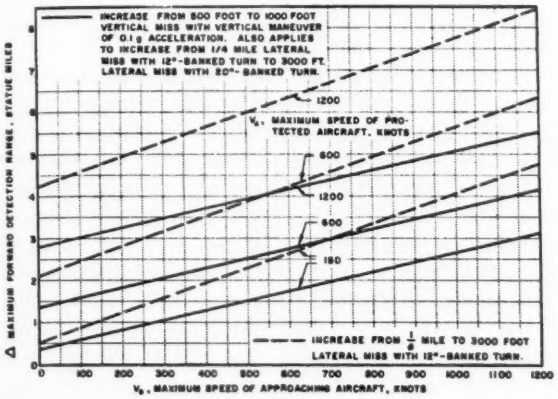
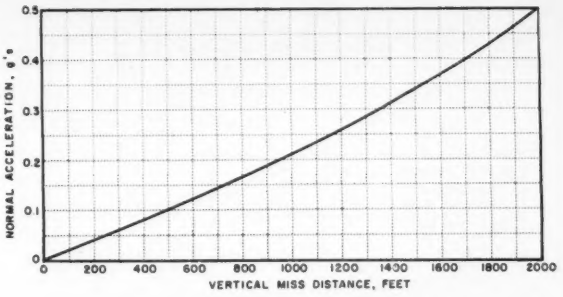
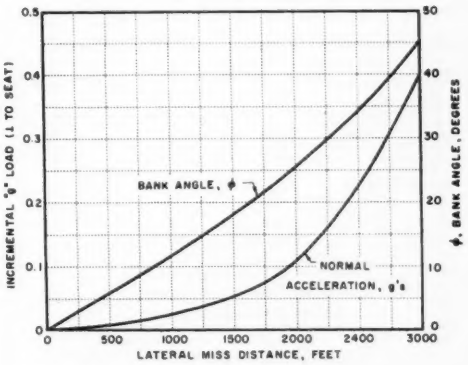

INCREASE FROM 500 FOOT TO 1000 FOOT VERTICAL MISS WITH VERTICAL MANEUVER OF 0.1 g ACCELERATION. ALSO APPLIES TO INCREASE FROM 1/4 MILE LATERAL MISS WITH 12°-BANKED TURN TO 3000 FT LATERAL MISS WITH 20°-BANKED TURN.
1200
V_A, MAXIMUM SPEED OF PROTECTED AIRCRAFT, KNOTS
600
1200
600
150
INCREASE FROM 1/4 MILE TO 3000 FOOT LATERAL MISS WITH 12°-BANKED TURN.
Δ MAXIMUM FORWARD DETECTION RANGE, STATUTE MILES
V_B, MAXIMUM SPEED OF APPROACHING AIRCRAFT, KNOTS

FIG. 4. Increase of maximum forward detection range caused by reduced system accuracy.

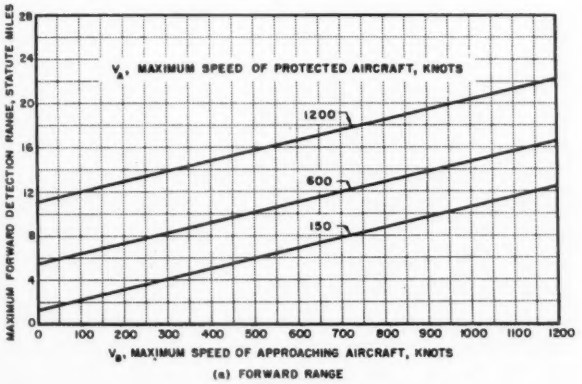


(a) VARIATION OF ACCELERATION IN VERTICAL MANEUVER, WITH MAXIMUM DETECTION RANGES GIVEN IN FIG. 3

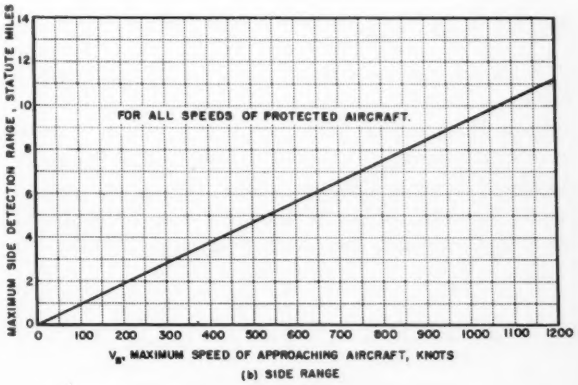


(b) VARIATION OF BANK ANGLE AND NORMAL ACCELERATION (PERPENDICULAR TO THE "SEAT") IN TURN MANEUVER WITH MAXIMUM DETECTION RANGES GIVEN IN FIG. 3

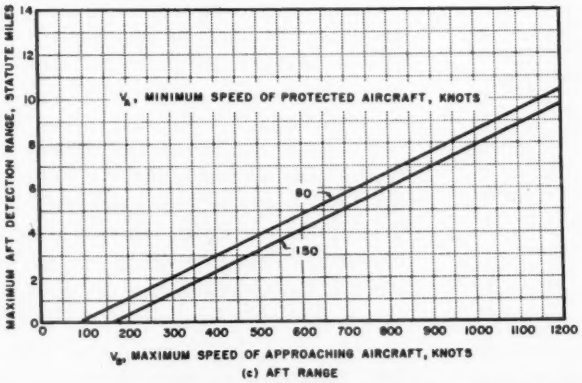
FIG. 5. Effect of increased miss distance requirements on avoidance maneuvers.



(a) FORWARD RANGE


FOR ALL SPEEDS OF PROTECTED AIRCRAFT.
MAXIMUM SIDE DETECTION RANGE, STATUTE MILES
V_B, MAXIMUM SPEED OF APPROACHING AIRCRAFT, KNOTS

(b) SIDE RANGE


V_A, MINIMUM SPEED OF PROTECTED AIRCRAFT, KNOTS
80
150
MAXIMUM AFT DETECTION RANGE, STATUTE MILES
V_B, MAXIMUM SPEED OF APPROACHING AIRCRAFT, KNOTS

(c) AFT RANGE

BASED ON 29 SECONDS FROM INITIAL DETECTION TO ACHIEVEMENT OF DESIRED MISS DISTANCE.

FIG. 3. Maximum horizontal range for initial detection to avoid collision.

TABLE I

PREDICTED 1965 FLEET CHARACTERISTICS

a. Air Carrier Transport Aircraft

Type	% of Fleet	Cruising Speeds Kn.	Cruising Altitudes ft.
Up to 50 passenger			
Piston types	15	150-380	5-12,000
Turboprop types	15	150-350	10-25,000
50-90 passenger			
Piston types	11	250-300	10-22,000
Turboprops	30	300-400	10-25,000
Turbojets	14	480-550	20-35,000
Over 90 passenger	15	480-550	20-35,000

b. General Aviation Aircraft

Type	% of Fleet	Cruising Speeds Kn.	Cruising Altitudes Ft.
"Light", Single Engine*	15	60-100	under 10,000
"Heavy", Single Engine*	25	100-150	under 10,000
"Light", Twin Engine*	29	120-180	under 10,000
"Heavy", Twin Engine*	15	120-180	under 10,000
Turbine powered, twin engine	16	250-500	10-40,000

* Piston types

c. Military Aircraft

Bombers: Small, Medium, Large
Transports: Small, Medium, Large
Fighters; Trainers; Helicopters

Assumed: (1) all turbine powered
(2) same fleet size as 1956

on actual traffic statistics, offers considerable flexibility in synthesizing additional useful data which may not exist and in analysis of the nature of the collision hazard.

The Air Traffic Model

A model was constructed based on air traffic which may be expected over the New York, N.Y., and Washington, D.C., terminal areas (defined as within 65 miles of the multiairport terminal centroid) and the route between them, in the year 1965. It was designed to give a picture of the traffic structure as it would appear at a single instant, with subsequent analysis based on estimations of probable occurrences following that instant. Traffic in each region of airspace was analyzed separately. The forecast statistics of the Curtis study[2-5] in combination with CAA air route traffic surveys were used to estimate the numbers and types of airborne aircraft in the regions. Data were also available[5,7] giving the distribution of flight directions from the terminals considered. Table I shows the kinds of aircraft existing in the airspace and the expected speed-altitude characteristics of the civil aircraft. Table II shows the structure of the traffic, including these types, during the peak hour of a typical busy day. In this model, aircraft are characterized as "local" if they take off and land at a single airport during a single flight, and "itinerant" if they take off and land at different airports during a single flight.

TABLE II

PREDICTED NUMBERS OF AIRCRAFT OF VARIOUS CATEGORIES SIMULTANEOUSLY AIRBORNE AT THE PEAK INSTANT OF A TYPICAL BUSY DAY, 1965

Category	New York, N.Y. Terminal Area*	Washington, D.C. Terminal Area*	Enroute Region
Air Carrier	30	25	16
General Aviation			
Itinerant	89	60	53
Local	22	15	99
Military			
Itinerant	46	31	13
Local	20	63	14
Helicopters	14	12	26
Total	221	206	221

* Within 65 miles of centroid of airport complex

Since air traffic regulations obviously have a great influence on the expectation of midair collisions, it was necessary to postulate a reasonable regulatory structure. The basic assumption in this structure was that *acceptance of control of course, speed, and altitude by ground-directed air traffic control procedures would continue to be optional for some classes of aircraft.*

It was also assumed that some form of speed regulation, fixing maximum flight speeds, would exist in the terminal area. This would permit normal low-altitude flight speeds of the aircraft having only low-altitude capability and normal climb and descent speeds of other aircraft, but would prohibit high-subsonic flight below 22,000 ft. and supersonic speed below 30,000 ft., within 65 statute miles of the terminal.

It was further assumed that, as indicated by present trends of regulation and practice,[8-10] all air carrier and itinerant military flights would be made with positive IFR-type control. In the case of general aviation, it was considered that, according to capability, mission, and current indications of practice and desire, only a relatively small percentage would fly under IFR-type control. The model was therefore constructed on the assumption that all general aviation aircraft were VFR. For similar reasons, the same assumption was applied to local military flights.

It is believed that the degree of air traffic control assumed is the minimum which may be expected in future years. The results obtained under these assumptions are conservative in that they represent a minimum restriction on flying activity and therefore a maximization of the collision hazard. The effect of changing the traffic control rules will be apparent from the analysis.

Within the limitations of assumed traffic rules, aircraft numbers, types, flight directions, and altitude capabilities, aircraft (three-dimensional) locations and headings in each of the three regions were chosen at random. Where appropriate, aircraft were considered ascending or descending, and altitudes were assigned where "known"—i.e., to all IFR aircraft. In accordance with the forecast data,[3,5] only an extremely small portion of terminal area itinerant flights were considered to be overflights.

TABLE III

NUMBER AND COMPOSITION OF "CRITICAL PAIRS"

Region	Critical Pairs	Critical Pairs with at least 1 VFR aircraft
Terminal	82	66%
Enroute	36	100%

The form taken by the model is indicated by the sample in Fig. 6. The relative density of aircraft in the altitude spectrum is indicated by the cumulative distributions in Fig. 7. It will be noted that over half of the aircraft exist below 10,000 ft. in the terminal areas; this occurs because of the large number of general aviation aircraft and because of the arrival and departure from the terminal of those of all classes. In the enroute model, natural segregation due to variation of performance characteristics is much more pronounced. Nevertheless, the relative population below 10,000 ft. is even greater than in the terminal area. This reflects the greater spread of altitudes among the higher-performance aircraft, as well as the large number of local general aviation flights.

The hypothetical traffic structure was examined for the following information: (1) What types of aircraft contribute to the collision hazard, and in what proportion? (2) Where in the airspace does the greatest danger of collision exist? In addition, a probability analysis indicated the number of collisions or near misses which may occur over a period of time.

Answers to these questions were obtained from consideration of "critical pairs." Any pair of aircraft within a given altitude band with any relative heading, separated by the greatest detection range, or less, corresponding to combined speed [Fig. 3(a)], was labeled a critical pair and was considered in danger of potential collision with some associated probability.

Types of Aircraft Involved

Table III shows that most critical pairs in the model include at least one aircraft in VFR flight (general aviation or local military). It is apparent that in the enroute model the rules for controlling IFR traffic would prohibit occurrence of critical pairs composed of two IFR aircraft. In the terminal area, approximately

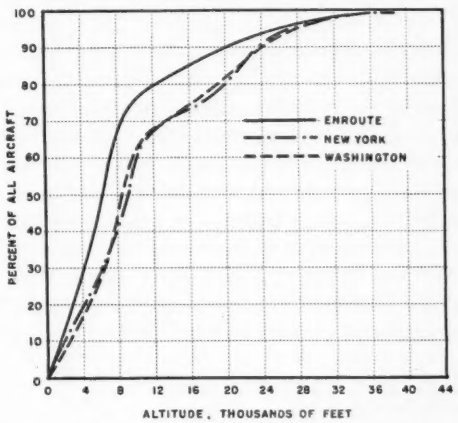
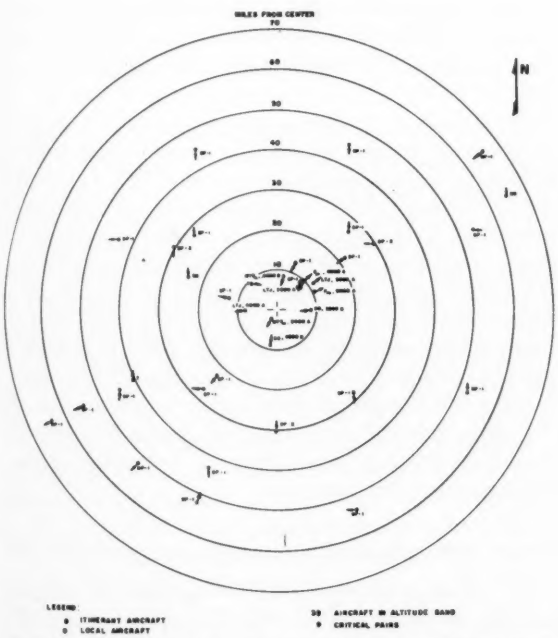
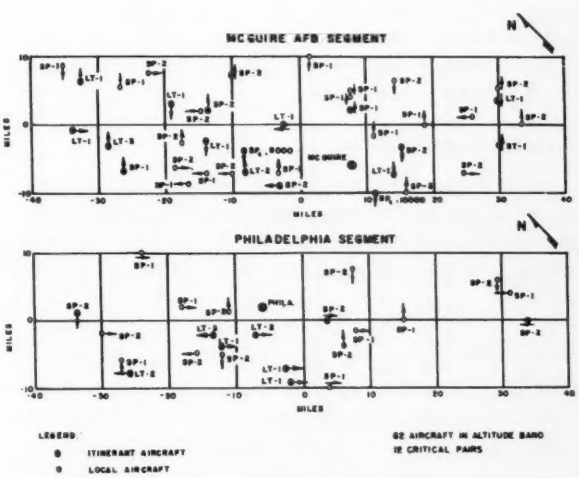


FIG. 7. Percentage of aircraft appearing below specific altitudes —cumulative distribution.

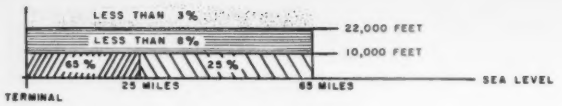


(a) WASHINGTON TERMINAL AREA, ALTITUDE BAND 2,000 TO 6,000 FEET



(b) ENROUTE, ALTITUDE BAND 6,000 TO 10,000 FEET.

FIG. 6. Typical traffic structure in air traffic model.
(Lettering at indicated aircraft position is code indicating type and altitude. Arrows indicate heading.)



(a) TERMINAL AREA

(b) ENROUTE

FIG. 8. Percentage of "critical pairs" appearing in various airspace regions.

75 per cent of critical pairs with both aircraft IFR are sufficiently close to the terminal to be in controlled approach or departure, and the risk of collision in those cases may be considered negligible. Thus, only about 10 per cent of all critical pairs in which a collision hazard remains include two IFR aircraft. Some 1955 statistics collected by the airlines[11] indicate that 7 per cent of all airline near-miss reports involved two aircraft on IFR flight plans, but no indication is given whether both aircraft were at their assigned altitudes and tracks. It is apparent that most collision or near-miss encounters occur between pairs of aircraft wherein at least one aircraft is flying VFR. It is also worth noting that virtually all the critical pairs which occur below 10,000 ft. in enroute airspace contain two low-performance general aviation aircraft.

Where Collisions Occur

Table III indicates more critical pairs in the terminal areas than enroute. However, the likelihood is that universal close control will be applied first in the terminal area. In that case, the enroute problem will become the more serious. The space distribution of critical pairs is shown in Fig. 8. Of the critical pairs appearing in the terminal area, approximately 65 per cent occur within 25 miles of the terminal—where aircraft of all kinds mix at low speed.

Expected Number of Collisions

Assume that the aircraft of the critical pair are flying on rectilinear courses and take no evasive action. The probability that the aircraft in the critical pair will collide or pass approximately one wing-span apart is given by

$$P = (4r^2/R\Delta h_2) \times (\Delta h_2/\Delta h_1)$$

where

- P = collision probability
- r = radius of a sphere including a single aircraft (taken here as 75 ft.)
- R = greatest detection range corresponding to combined speed
- Δh_1 = altitude range within which the first aircraft can exist
- Δh_2 = altitude range within which the second aircraft can exist

The expected number of collisions or near misses on the order of one wing-span apart in the time interval represented by the model (corresponding to R, or 25–30 sec.) is

$$E = \sum_{i=1}^{N} P_i$$

where N is the number of critical pairs.

The present model shows a collision or near-miss expectation of just under 0.01 for each of the three airspace regions considered, after the small number of critical pairs having two IFR aircraft is eliminated. Calculation of E, considering that all the aircraft over a terminal area are distributed at random in a volume 50,000 ft. high and 65 miles in radius, gives an expectation of about 0.02 in the same time. The random model shows, furthermore, that E is proportional to the square of the number of aircraft n in the airspace.[1] Thus, the random distribution leads to the same order of collision expectancy as the original model, and all the regions of the latter, with approximately equal numbers of airborne aircraft, yield comparable results. Therefore, although statistically the traffic sample is small, the results obtained therefrom appear consistent.

Using the relation $E \propto n^2$, integrating E over the terminal-area distribution of n during a day and year,[3] and applying the E proportionality to the numbers of aircraft appearing within 65 miles of 171 cities[12] (under the assumption that n is proportional to the number of movements at those cities), leads to the result that 10,000 collisions or near misses will occur over the United States during 1965 under the assumed conditions. On the basis of approximately 1,600 near misses or collisions that were reported in 1955[13] and expected doubling (approximately) of the number of airborne aircraft by 1965,[3] the 1,600 will increase to 6,400. This is of the same order of magnitude as the figure obtained from the model.

These estimates of expected dangerous encounters cannot be considered as forecasts because they depend so heavily on the assumptions regarding VFR flying and evasive action. But it becomes apparent that the number of collisions or near misses can be reduced in direct proportion as VFR aircraft are eliminated from the critical pairs or as the capability of aircraft in a critical pair to take evasive action is perfected. If it is assumed that equipping one aircraft of the pair with a collision avoidance device or eliminating VFR aircraft in the pair is equally effective and assures reduction of P to zero, then the decision on which step to take will depend on considerations of technical feasibility, operational practicability, and cost.

USE OF AIRBORNE DEVICES FOR COLLISION AVOIDANCE

The physical requirements for collision avoidance may now be considered vis-à-vis the nature of the collision hazard to explore how the collision risk may be significantly reduced through the use of airborne equipment. Manufacturers of such equipment have found

that the accuracy requirements for self-contained systems to detect, evaluate, and indicate the maneuvers to avoid collision threats at high speed are so difficult as to be incapable of fulfillment within present technological capability.[6] The present analysis of a traffic model indicates that the greatest number of potential collisions may be eliminated through use of equipment with more modest requirements of range, and therefore accuracy. Fig. 9, which applies to the entire aircraft population in the present model, shows that a universally used collision avoidance system with a maximum usable range of 4 miles would provide warning to avert about 90 per cent of all potential collisions in the present model.

If an aircraft desires protection against collision threats requiring greater detection ranges, then the requirements shown in Figs. 3, 4, and 5 must be fulfilled. It has been suggested frequently that such protection may be afforded by cooperative collision avoidance systems, which depend on data transfer between aircraft and thereby permit meeting the stringent accuracy requirements so difficult to achieve with self-contained systems. It is apparent that universal installation of equipment for such a system is unlikely because the majority of the aircraft flying are, and will be, relatively inexpensive, low-performance types[5] for which such equipment may be expensive and therefore unattractive.

Suppose, however, that all air carrier and military aircraft and the general aviation aircraft of the "heavy" twin and turbine-powered groups [Table I(b)] were to carry a perfect cooperative collision avoidance system. Then, the traffic model shows, about one third of the expected collisions, or virtually all those above 10,000 ft. and about 25 per cent of those below 10,000 ft., would be averted. Thus, the collision danger at relatively high speed and altitude may be eliminated, but the greatest part of the total collision hazard (Fig. 8) will barely have been affected.

It may be that, since most collisions occur in good weather[11, 14] and the equipment requirements appear to be generally modest in most cases, simple proximity warning systems which may alert the pilot to a threat 2 to 7 miles away,[6] combined with means to provide visibility from the cockpit in all directions, could help avoid collisions and near misses. These systems may help the pilot see the threatening aircraft. He will, however, have to evaluate the nature of the threat and take the proper evasive action. This task remains difficult since the bearing or closure rate estimations remain difficult in situations of danger and it is possible for evasive action improperly taken to create a threat of collision where none previously existed.[15] The difficulty may be alleviated through establishment of a foolproof rules-of-the-road convention by extending the rules now existing in the civil air regulations. If such rules assure that pilots take the correct evasive action, whether one aircraft maneuvers or both, then precautionary actions may be taken in situations of doubt; even if many are unnecessary, they will nevertheless assure collision avoidance in the smaller number of situations requiring it.

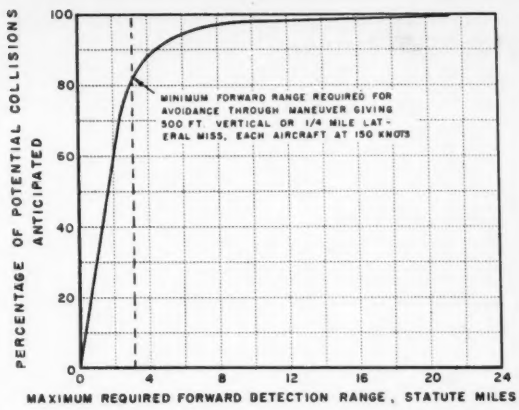


FIG. 9. Percentage of collisions anticipated by systems with various maximum ranges.

Establishing a maneuvering convention is not a simple problem, however. A requirement for altitude change, up or down, depending on the bearing or heading quadrants in which the respective aircraft observe each other, could lead to a foolproof convention because the observing aircraft is assured of avoiding the observed aircraft whether or not the latter maneuvers within the rules of the convention. However, situations may be foreseen in which altitude changes are not possible. While it may always be possible to specify a turning maneuver whereby the turning aircraft avoids collision if the other does not maneuver, it appears difficult, from a cursory analysis, to specify in all cases simultaneous turning maneuvers which may not cancel each other. And it is obvious that both aircraft may turn since neither pilot may be assured that the other has observed him. It should also be noted that in crowded airspace, even though an aircraft performs the proper maneuver to avoid collision with one aircraft, the maneuver itself may bring it into conflict with another. Thus the convention must consider the possibility of multiple encounters.

CONCLUSIONS

The foregoing analysis has been based on the assumption that air traffic rules and practice will continue to permit, everywhere, the option of VFR flight for some classes of aircraft. The resulting conclusions may be summarized as follows:

(1) The greatest danger of collision or near miss results from encounters between pairs of aircraft wherein at least one of the pair is in VFR flight.

(2) Reduction of VFR flying or perfection of the capability for taking evasive action might be equally effective in reducing the risk of collision. The decision regarding which step to take then depends on considerations of technical feasibility, operational practicability, and cost.

(3) The greatest danger of collision or near miss occurs below 10,000 ft., in the terminal area, among aircraft

of all kinds traveling at low speed. If VFR flying is eliminated in major terminal areas, about three quarters of all potential collisions may be avoided. Then the greatest hazard will occur in enroute airspace and involve mainly general aviation aircraft at altitudes below 10,000 ft.

(4) An airborne collision avoidance system, universally used and perfectly effective, having a maximum usable range of 4 miles, would help avoid about 90 per cent of potential collisions and near misses.

(5) Use of cooperative collision avoidance systems by all air carrier, military, and higher performance general aviation aircraft, to by-pass the technical difficulties of self-contained systems, may virtually eliminate the collision hazard above 10,000 ft. at relatively high speeds but would have only a small effect on the risk of collision in the regions of greatest danger.

(6) Proximity warning systems may help reduce significantly the collision hazard in the most dangerous regions of airspace, provided pilots are aided by a universally used foolproof maneuvering convention. Establishment of such a convention, is however, a difficult task.

(7) If in the future IFR-type control is required in all major terminal areas, then proximity warning systems, limited in practical range to approximately 5 miles, will be useful only to low-performance general aviation aircraft in enroute airspace below about 10,000 ft.

References

[1] Deitchman, S. J., *Requirements for an Airborne Aircraft Collision Warning System*, Cornell Aeronautical Lab., Inc., Report No. JA-1122-G-1, Jan., 1957.

[2] *National Requirements for Aviation Facilities; 1956–75; Volume I, Summary*, U.S. Government Printing Office, May, 1957.

[3] *National Requirements for Aviation Facilities; 1956–75; Volume II, Air Traffic*, U.S. Government Printing Office, May, 1957.

[4] *National Requirements for Aviation Facilities; 1965–75; Volume III, Aircraft Characteristics*, U.S. Government Printing Office, May, 1957.

[5] *National Requirements for Aviation Facilities; 1965–75; Volume IV, Forecast of Aviation Activity*, U.S. Government Printing Office, June, 1957.

[6] *Summary, Research and Development on Aircraft Proximity Warning and Collision Avoidance Techniques*, Bendix Radio Div., Bendix Aviation Corp., April, 1958.

[7] CAB, *Origin-Destination Airline Revenue Passenger Survey*, Sept. 17–30, 1955.

[8] *Positive Air Traffic Control Experiment*, Special Civil Air Regulation No. SR-424, June 15, 1958.

[9] *Technical Talk for Pilots*, Air Line Pilots Assn., Bulletin No. 58-8, July 7, 1958.

[10] *Visual Flight Rule Minimums . . ., and Speed Control and Communication Rules in High Density Air Traffic Zones*, Civil Air Regulations, Part 60, Air Traffic Rules, Amendment 60-2, March 15, 1957.

[11] Jenson, W., *Near Miss Data*, presented at CAA-TDEC Mid-Air Collision Symposium, Nov., 1955.

[12] *Federal Airways Air Traffic Activity, Fiscal Year 1954*, Dept. of Commerce, CAA, Office of Program Coordination.

[13] *Collected Papers*, CAA-TDEC Mid-Air Collision Symposium, Nov. 1955.

[14] CAB, *The Advance in Air Safety*, Supplemental Report, May, 1958.

[15] Calvert, E. S., *Some Operational Aspects of the Use of Air-screw-Interpreted Devices for Preventing Collision in the Air*, presented at second meeting, Airworthiness Committee, ICAO, Montreal, July, 1958.

✦ ✦ ✦

SUGGESTION FOR BINDING ISSUES OF AERO/SPACE ENGINEERING

Arrangements have been made so that our readers may have their issues bound carefully and economically in our authorized binding. Simply write for details to:

Publishers' Authorized Bindery Service, 5809 West Division St., Chicago 51, Ill.

NATIONAL NAVAL AVIATION MEETING PROCEEDINGS

The *Proceedings* of the Naval meeting (held in San Diego, Calif., August 5–10, 1957) contains all *unclassified* papers presented at the meeting and is now available.

Member Price: $3.00 **Nonmember Price: $5.00**

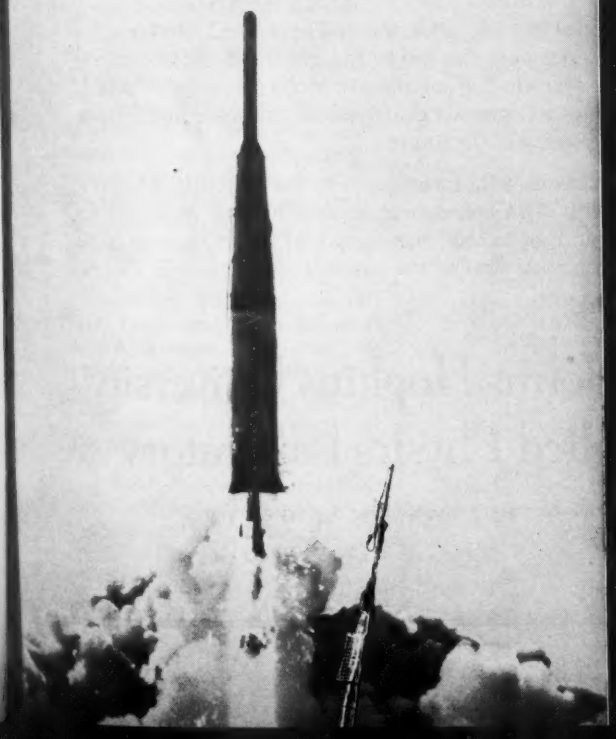
Special Publications Dept., Institute of the Aeronautical Sciences, Inc., 2 East 64th St., N.Y. 21, N.Y.

the Pioneer in space

To send the U. S. Pioneer more than 60,000 miles into interplanetary space, Space Technology Laboratories in seven months designed, developed, assembled, and sted an 88-foot combination of three integrated stages with a payload incorporating 36 separate ignition systems. 's Astrovehicles Laboratory focused on the payload itself and the sensitively related problems of propulsion, weight, nd stability. These are in addition to the overall complexities of the structural configuration.

Pioneer, setting new apogees in science and missilery, pifies the achievements STL is making in the advancement of space technology. Those who are able to contribute to and benefit from these developments are invited to consider joining our staff.

Space Technology Laboratories



Members of STL's
senior technical staff
will be available for personal interviews
at the
Institute's 27th Annual Meeting,
Hotel Astor, New York City,
January 26-29, 1959.

Space Technology Laboratories, Inc.
5730 Arbor Vitae Street, Los Angeles 45, California

Frontiers are extended by the practical visionary

It is the practical visionary who has given us much of what we enjoy today. And it will be the visionary—the man with ability to seek concepts beyond the existing limitations of science —who will guide our developments of tomorrow.

The Applied Physics Laboratory (APL) of The Johns Hopkins University seeks men who will be engaged in advanced research problems—who will find solutions to problems yet to be posed. Their findings will provide guidelines for the space and missile hardware research of the future.

Your endeavors will be heightened by the professional atmosphere of APL. This atmosphere, created by men dedicated to the furtherance of science, has earned APL a reputation as a leader in programs vital to the national security.

Appointments at APL offer exceptional opportunities. For detailed information, address your inquiry to:

Professional Staff Appointments

The Johns Hopkins University Applied Physics Laboratory

8605 Georgia Avenue, Silver Spring, Maryland

AERO/SPACE Reviews

. . . current literature of aeronautical engineering and space technology

THIS SECTION reviews important periodicals, technical and research reports, and books received in the IAS Library in order to provide basic documentation for engineers and scientists.

INTERNATIONAL AERONAUTICAL ABSTRACTS, published as an insert in each issue, is an accelerated reviewing service covering worldwide scientific and technical literature. This work is performed by the IAS Staff and is supported by the Air Force Office of Scientific Research of the Air Research and Development Command.

A list of the principal periodicals received in the IAS Library is published annually in the January issue.

The AERO/SPACE ENGINEERING INDEX, formerly the AERONAUTICAL ENGINEERING INDEX published since 1947, provides an annual cumulation of the materials reviewed in this section.

THE IAS LIBRARY

Publications reviewed in this section are maintained by the Library for use by the IAS Membership. They are *not* for sale but are made available through the facilities of the Library.

LENDING SERVICES: Institute members, both Individual and Corporate, may borrow periodicals, reports, and books for a period of 2 weeks, excluding time in transit. Excepted are certain reference books and those IAS publications that may be purchased.

PHOTOCOPY SERVICES: The Library is equipped to provide, as a service, positive photocopies of certain materials in its collections. Rates on request.

For detailed information about these and other services, write to:

John J. Glennon, Librarian
Institute of the
Aeronautical Sciences, Inc.
2 East 64th Street
New York 21, New York

LIST OF PERIODICALS 64
PERIODICALS AND REPORTS 70
INTERNATIONAL AERONAUTICAL ABSTRACTS. 91
BOOKS 115

Subject Index to Periodicals & Reports

Acoustics, Sound, Noise 70
Aerodynamics, Fluid Mechanics
  Aerothermodynamics 70
  Boundary Layer 70
  Control Surfaces 70
  Flow of Fluids 70
  Internal Flow 72
  Stability & Control 72
  Wings & Airfoils 72
Aeroelasticity 72
Aeronautics, General 72
Air Transportation 72
Airplanes
  Air Conditioning, Pressurization 73
  Control Systems, Automatic Pilots ... 73
  Description 73
  Design 73
  Ejection Seats 74
  Fuel Tanks 74
  Landing, Landing Loads 74
  Landing Gear 74
  Operating Characteristics, Economics 74
  Piloting 74
Airports 74
  Heliports 74
Aviation & Space Medicine 74
Chemistry 74
Computers 74
Control Theory 76
Education & Training 76
Electronics
  Amplifiers 76
  Antennas, Radomes 76
  Circuits & Components 76
  Communications 76
  Cooling 76
  Electronic Tubes 76
  Magnetic Devices 76
  Networks, Filters 76
  Noise, Interference 76
  Piezoelectricity 79
  Power Supplies 79
  Radar 79
  Reliability 79
  Semiconductors 79
  Telemetry 80
  Transmission Lines 80
  Wave Propagation 80
Equipment
  Electric 80
  Hydraulic & Pneumatic 80
Fuels & Lubricants 80
Ice Formation & Prevention 80
Instruments 80
  Flow Measuring Devices 80
  Gyroscopes 80
  Pressure Measuring Devices 82
  Recording Equipment 82
  Stress & Strain Measuring Devices ... 82
  Tachometers 82
  Temperature Measuring Devices 82
  Vibration Measuring Devices 82
Laws & Regulations 82
Machine Elements
  Bearings 82
  Rotating Discs & Shafts 82
Maintenance 82
Materials 82
  Ceramics & Ceramals 82
  Corrosion & Protective Coatings 83
  High Temperature 83
  Metals & Alloys 83
  Metals & Alloys, Nonferrous 83
  Nonmetallic Materials 83
  Testing Methods 84
Mathematics 84
Mechanics 86
Meteorology 86
  Atmospheric Structure & Physics 86
  Upper Air Research 86
Missiles, Rockets 86
Navigation 88
  Traffic Control 88
Nuclear Energy 88
Parachutes 107
Photography 107
Physics 107
Power Plants 107
  Jet & Turbine 107
  Ram-Jet & Pulse-Jet 108
  Reciprocating 108
  Rocket 108
Production 108
  Metalworking 108
  Production Engineering 108
  Tooling 108
Propellers 108
Research, Research Facilities 108
  Flight Testing 110
  Wind Tunnels 110
Rotating Wing Aircraft, Helicopters ... 110

XUM

List of Periodicals

The publications listed below represent periodicals currently received in the IAS Library for abstracting in the Aeronautical Reviews Section, including International Aeronautical Abstracts. Information includes the publisher's address, the frequency of publication, and, in most cases, the annual subscription cost to recipients in the United States. The frequency of publication is indicated as follows: BM, bimonthly; BW, biweekly; Irreg., irregularly; M, monthly; Q, quarterly; SA, semiannually; W, weekly.

These periodicals are maintained in the IAS Library and are made available through its lending, photocopy, and reference facilities. The IAS Library does not sell these publications.

Acad. Pol. Sci. Bul. Académie Polonaise des Sciences, Bulletin, Sniadeckich 8, Warsaw 10, Poland, Irreg.

Acta Metallurgica, 122 E. 55th St., New York 22, N.Y., M, $16

Acta Metallurgica Sinica, Academia Sinica, Peking, China, Q

Acta Physica Sinica, Academia Sinica, Peking, China, BM

Acta Polytechnica Scandinavica, Box 5073, Stockholm 5, Sweden, Irreg.

Acta Technica, Československá Akademia Ved, Vodičkova 40, Prague 2, Czechoslovakia, BM, 78 kčs.

Aero, Herman Lingg Strasse 9, Munich 15, Germany, M, DM 12

Aero. Eng. Rev. Aeronautical Engineering Review. Institute of the Aeronautical Sciences, Inc., 2 E. 64 St., New York 21, N.Y., M, $3

Aéro France. Aéro Club de France, 6, rue Galilée, Paris 16, France, M, 1,200 fr.

Aero Mag. Aero Magazine (Supplement to Velocidade), Caixa Postal 4917, São Paulo, Brazil, M, Cr$200 (2 years)

Aero. Procurement. Aeronautical Procurement, 812 Huron Rd., Cleveland 15, Ohio, M, $10

Aero. Quart. Aeronautical Quarterly. Royal Aeronautical Society, 4 Hamilton Place, London W 1, England, Q, $8.55

Aero. Soc. of India J. Aeronautical Society of India, Journal, New Delhi, India, Q, $2

Aeronautics, Tower House, Southampton St., Strand, London WC 2, England, M, 33s.

Aéronaves, Edificio Zingg, Caracas, Venezuela, BM

The Aeroplane, Bowling Green Lane, London EC 1, England, W, $14

Aeroporika Nea, 4 Othonos St., Athens, Greece, M

L'Aerotecnica. Associazione Italiana di Aerotecnica, Piazza S. Bernardo 101, Rome, Italy, M, L.3,000

Aerovox Res. Worker. Aerovox Research Worker. Aerovox Corp., New Bedford, Mass., M

Les Ailes, 77, blvd. Malesherbes, Paris 8, France, W, 1,200 fr.

L'Air, 71 Champs-Elysées, Paris 8, France, M, 1,500 fr.

Air Age, Mehta House, Apollo St., Bombay 1, India, BM, 12 rupees

Air BP. The British Petroleum Co., Ltd., Finsbury Circus, London, EC 2, England, Q

Air Facts, 30 Rockefeller Plaza, New York 20, N.Y., M, $3

Air Force, Air Force Assn., Mills Bldg., Washington 6, D.C., M, $4

Air Line Pilot, Air Line Pilots Assn., International, 55 St. & Cicero Ave., Chicago 38, Ill., M, $2.50

Air Pictorial, Air League of the British Empire, Londonderry House, 19 Park Lane, London W1, England, M, $3.50

Air Rev. Air Revue, 11 rue de Crayer, Brussels, Belgium, M, 350 fr. belge

Air Safety Dig. Air Safety Digest. Flight Safety Foundation, 468 4th Ave., New York 16, N.Y., Q

Air Transp. Air Transportation, 10 Bridge St., New York 4, N.Y., M, $5

Air U. Quart. Rev. Air University Quarterly Review, Maxwell AFB, Ala., Q, $2

Aircraft (Australia). Royal Aeronautical Society, Australian Division, etc., 26 Flinders St., Melbourne, Australia, M, 30s.

Aircraft (Canada), 341 Church St., Toronto 2, M, $5

Aircraft & Missiles Mfg. Aircraft and Missiles Manufacturing, Chestnut and 56th Sts., Philadelphia 39, Pa., M, $5

Aircraft Eng. Aircraft Engineering, 12 Bloomsbury Sq., London WC 1, England, M, 40s.

Aircraft Heating Dig. Aircraft Heating Digest. Janitrol Aircraft-Automotive Division, Surface Combustion Corp., Columbus 16, Ohio, Irreg.

Aircraft Maintenance Engrg. Aircraft Maintenance Engineering, Japan Aeronautical Engineer's Association, Hikokan, No. 3, 1-chome, Shiba-tamura-cho, Minato-ku, Japan, M

Aircraft Prod. Aircraft Production, Dorset House, Stamford St., London SE 1, England, M, $6

Airplane Patent Dig. Airplane Patent Digest. Manufacturers Aircraft Assn., Inc., 45 Rockefeller Plaza, New York 20, N.Y., SM

Airports & Airport Eng. Airports & Airport Engineering, 92 Victoria St., London, SW 1, England, BM, 15s.

Allis-Chalmers Elec. Rev. Allis-Chalmers Electrical Review. Allis-Chalmers Mfg. Co., Milwaukee, Wis., Q, $2

AHS J. American Helicopter Society, Journal, 2 E. 64 St., New York 21, N.Y., Q, $4

AHS Newsletter. American Helicopter Society, Newsletter, 2 E. 64 St., New York, 21 N.Y., M, $3

Am. Av. American Aviation, 1001 Vermont Ave., NW, Washington 5, D.C., SM, $5

Am. Ceram. Soc. Bul. American Ceramic Society, Bulletin, 4055 North High St., Columbus 14, Ohio, M, $6

Am. Ceram. Soc. J. American Ceramic Society, Journal (incl. **Ceramic Abstracts**), 4055 North High St., Columbus 14, Ohio, M, $14

Am. Engr. American Engineer. National Society of Professional Engineers, 2029 K St., NW, Washington 6, D.C., M, $3

Am. Helicopter. American Helicopter, 32 E. 57 St., New York 22, N.Y., M, $3.50

AMS Bul. American Meteorological Society, Bulletin, 3 Joy St., Boston 8, Mass., 10 issues per year, $8

AN SSSR Dokl. Akademiia Nauk SSSR, Doklady, Moscow, U.S.S.R., 36 issues per year

AN SSSR Lab. Aerometedov Trudy. Akademiia Nauk SSSR, Laboratorii Aerometedov, Trudy, Moscow, U.S.S.R., Irreg.

AN SSSR Mat. Inst. Trudy. Akademiia Nauk SSSR, Matematicheskii Institut, Trudy, Moscow, U.S.S.R., Irreg.

AN SSSR Otd. Tekh. Nauk Izv. Akademiia Nauk SSSR, Otdelenie Tekhnicheskikh Nauk, Izvestiia, Moscow, U.S.S.R., M

AN SSSR Vestn. Akademiia nauk SSSR, Vestnik, Moscow, M

Anal. Chem. Analytical Chemistry. American Chemical Society, 1155 16th St. NW, Washington 6, D.C., M, $4.50

Annals Phys. Annals of Physics, 111 5th Ave., New York 3, N.Y., M, $22

AOPA Pilot, Aircraft Owners and Pilots Association, 4644 East-West Highway, Bethesda 14, Md., M, $8

Appl. Hydraulics. Applied Hydraulics, 1240 Ontario St., Cleveland 13, Ohio, M, $5

Appl. Mech. Rev. Applied Mechanics Reviews. Southwest Research Institute, 8500 Culebra Rd., San Antonio 6, Tex., M, $25

Appl. Sci. Res., Sect. A. Applied Scientific Research, Section A, 9 Lange Voorhout, The Hague, Netherlands, Irreg., 21.50 guilder

Appl. Sci. Res., Sect. B. Applied Scientific Research, Section B, 9 Lange Voorhout, The Hague, Netherlands, Irreg., 21.50 guilder

Approach. U.S. Naval Aviation Safety Center. Supt. of Documents, Washington 25, D.C., M, $2.50

Arch. Budowy Maszyn. Archiwum Budowy Maszyn. Polska Akademia Nauk, ul. Nowy Swiat 72, Warsaw, Poland, Q, 80 zl.

Arch. Mech. Stosowanej. Archiwum Mechaniki Stosowanej. Polska Akademia Nauk, ul. Nowy Swiat 72, Warsaw, Poland, Q, 100 zl.

Argentina Aérea, Moreno 360, Buenos Aires, Argentina, M, $3

Arma Eng. Arma Engineering. Arma Div., American Bosch Arma Corp., Roosevelt Field, Garden City, N.Y., BM

Armed Forces Management, 1001 Vermont Ave., N.W., Washington 5, D.C., M, $10

ASA J. Acoustical Society of America, Journal, 334 E. 45th St., New York 17, N.Y., M, $14

ASEA Journal. ASEA, Västerås, Sweden, M

ASME Trans. American Society of Mechanical Engineers, Transactions, 29 W. 39 St., New York 18, N.Y., 8 issues per year, $12

Asoc. Argent. Interplan. Rev. Asociación Argentina Interplanetaria, Revista, Viamonte 867, Buenos Aires, Argentina, Q

Assoc. Comp. Mach. J. Association for Computing Machinery, Journal, 2 E. 63rd St., New York 21, N.Y., Q, $10

ASTM Bul. American Society for Testing Materials, Bulletin, 1916 Race St., Phila. 3, Pa., 8 issues per year, $2.75

Astronautica Acta, Molkerbastei 5, Vienna 1, Austria; I. R. Maxwell & Co., Ltd., London, Paris, New York, Q, $8.60

Astronautics. American Rocket Society, 500 5th Ave., New York 36, N.Y., M, $9

Auster News. Auster Aircraft Ltd., Rearsby Aerodrome, Leicester, Eng., Q

Australian J. Appl. Sci. Australian Journal of Applied Science. Commonwealth Scientific & Industrial Research Organization, 314 Albert St., East Melbourne C.2, Victoria, Australia, Q, £2

Australian J. Phys. Australian Journal of Physics. Commonwealth Scientific and Industrial Research Organization, 314 Albert St., East Melbourne C.2., Australia, Q, 30s.

Auto. Control. Automatic Control, 430 Park Ave., New York 22, N.Y., M, $10

Auto. Ind. Automotive Industries, Chestnut & 56 Sts., Phila. 39, Pa., SM, $2

Automation and Remote Control (The Soviet Journal *Avtomatika i Telemekhanika* in English Translation), Instrument Society of America, 313 Sixth Ave., Pittsburgh 22, Pa., M, $30

Av. Age. Aviation Age, 205 E. 42 St., New York 17, N.Y., M, $10

Av. Daily. Aviation Daily, 1001 Vermont Ave., N.W., Washington 5, D.C., Daily, $200

Av. Mech. Bul. Aviation Mechanics Bulletin. Flight Safety Foundation, Inc., 468 Fourth Ave., New York 16, N.Y., BM, $1.20

Av. Week. Aviation Week, 330 W. 42 St., New York 36, N.Y., W, $6

Avia Vliegwereld. Royal Aero Club of the Netherlands, Anna Paulownaplein 3, The Hague, Netherlands, BW, 11 fl.

Aviação, Rua Uruguaiana 104-4, Rio de Janeiro, Brazil, M, Cr$600

Aviation Week Market Letter, 330 W. 42 St., New York 36, N.Y., M

Avión. Reál Aéro Club de España, Carrera de San Jerónimo 19, Madrid, Spain, M, 250 pesetas

Avtom. i Telemekh. Avtomatika i Telemekhanika. Institut Avtomatiki i Teemekhaniki, Otdelenie Tekhnicheskikh Nauk, Akademiia Nauk SSSR, Moscow, U.S.S.R., M

Battelle Tech. Rev. Battelle Technical Review. Battelle Memorial Institute, 505 King Ave., Columbus 1, Ohio, M

Bearing Engr. Bearing Engineer. The Torrington Company, 444 Madison Ave., New York 22, N.Y., Irreg.

Bee Hive, United Aircraft Corp., East Hartford, Conn., Q

Bell System Tech. J. Bell System Technical Journal. American Telephone and Telegraph Co., 195 Broadway, New York 7, N.Y., BM, $3

BOAC Review. British Overseas Airways Corp., Stratton House, Piccadilly, London W 1, England, M

Boeing Mag. Boeing Magazine. Boeing Airplane Co., 7755 E. Marginal Way, Seattle, Wash., M

Bristol Quart. The Bristol Quarterly. Bristol Aeroplane Company, Ltd., Filton House, Bristol, England, Q

Brit. Aircraft Ind. Bul. British Aircraft Industry Bulletin. Society of British Aircraft Constructors, 29 King St., St. James, London SW 1, England, Q

Brit. Interpl. Soc. J. British Interplanetary Society, Journal, 12 Bessborough Gardens, London SW 1, England, BM, 24s.

Brit. J. Appl. Phys. British Journal of Applied Physics. Institute of Physics, 47 Belgrave Sq., London SW 1, England, M, $11.50

Brit. Welding J. British Welding Journal. Institute of Welding, 2 Buckingham Gardens, London, SW 1, England, M, £5

Brown Boveri Rev. Brown Boveri Review. Brown, Boveri & Co., Ltd., Baden, Switzerland, M

Bul. Liais. Doc. Bulletin de Liaison et de Documentation du Secrétariat Général à l'Aviation Civile et Commerciale, 93 blvd. du Montparnasse. Paris 6, France, BM

Bul. Stiint. Sect. Stiinte Mat. Fiz. Bulletin Stiintific, Sectiunea de Stiinte Matematice si Fizice, Academia Republicii Populare Romine, Bucarest, Rumania, Q

Business/Commercial Aviation, 205 East 42nd St., New York 17, N.Y., M, $10

BWK. Brennstoff-Wärme-Kraft. VDI-Verlag, Bongardstrasse 3, Düsseldorf, Germany, M, DM 52

Cambridge Philos. Soc. Proc. Cambridge Philosophical Society, Proceedings, Free School Lane, Cambridge, England, Q, £5

Can. Aero. J. Canadian Aeronautical Journal. Canadian Aeronautical Institute. Commonwealth Building, 77 Metcalfe St., Ottawa, Canada, M, $4

Can. Aircraft Ind. Canadian Aircraft Industries, 405 Alliance Ave., Toronto 9, Ontario, Canada, M, $5

Can. Airline Pilot. The Canadian Airline Pilot. The Canadian Airline Pilots Assn., 400 Electric Railway Chambers, Winnipeg, Manitoba, Canada. Q

Can. Flight. Canadian Flight, Canadian Owners & Pilots Assn., Box 734, Sta. B, Ottawa, Ont., Canada, BM, $4

Can. J. Chem. Canadian Journal of Chemistry, National Research Council, Ottawa 2, Canada, M, $5

Can. J. Phys. Canadian Journal of Physics. National Research Council, Ottawa 2, Canada, M, $4

Canada, NAE Quart. Bul. Canada, National Aeronautical Establishment, Quarterly Bulletin, Montreal Road, Ottawa, Canada, Q

CEC Recordings. Consolidated Electrodynamics Corp., 300 North Sierra Madre Villa, Pasadena, Calif., BM

Ceramic Abstracts (see **Am. Ceram. Soc. J.**)

Chalmers Tek. Högskolas Handlingar. Chalmers Tekniska Högskolas, Handlingar, Gothenburg, Sweden, Irreg.

Chartered Mech. Engr. The Chartered Mechanical Engineer; The Journal of the Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, London SW 1, England, 10 issues per year, £2, 5s. 6d.

Climatological Data. U.S. Weather Bureau. Superintendent of Documents, Washington 25, D.C., M, $4

Collins Signal. Collins Radio Company, Cedar Rapids, Iowa, Q

Comb. & Flame. Combustion and Flame. The Combustion Institute. Butterworths Scientific Publications, 4-5 Bell Yard, Temple Bar, London, WC 2, England; Interscience Publishers, Inc., 250 Fifth Ave., New York 1, N.Y., Q, £5, 5s., $16

Commun. on Pure & Appl. Math. Communications on Pure and Applied Mathematics. Institute of Mathematical Sciences, New York University. Interscience Publishers, Inc., 250 Fifth Ave., New York 1, N.Y., Q, $8

Connecting Link. Link Aviation, Inc., Binghamton, N.Y., Irreg.

Cook Tech. Rev. Cook Technical Review, Cook Electric Co., 2700 N. Southport Ave., Chicago 14, Ill., Irreg.

Czech. J. Phys. Czechoslovak Journal of Physics, Nakladatelstvi ČSAV, Vodičkova 40, Prague 2, Czechoslovakia, Q

Czech. Math. J. Czechoslovak Mathematical Journal, Matematický Ústav ČSAV, Žitná 25, Prague 2, Czechoslovakia, Q, 120 kčs.

Data Processing Digest. Canning, Sisson, & Associates, 914 South Robertson Blvd., Los Angeles 35, Calif., M, $24

de Havilland Gazette. de Havilland Enterprise Hatfield, Herts, England, Q

Des. News. Design News, 3375 S. Bannock, Englewood, Colo., SM, $20

Docaéro. Service de Documentation et d'Information Technique de l'Aéronautique (SDIT), 2, avenue de la Porte d'Issy, Paris 15, France, BM

Douglas Serv. Douglas Service. Douglas Aircraft Co., Inc., 3000 Ocean Park Blvd., Santa Monica, Calif., BM

Elec. Commun. Electrical Communication. International Telephone and Telegraph Corp., 67 Broad St., New York 4, N.Y., Q, $2

Elec. Energy. Electrical Energy, 28 Essex St., Strand, London WC 2, England, M, $5

Elec. Eng. Electrical Engineering. American Institute of Electrical Engineers, 33 W. 39 St., New York 18, N.Y., M, $12

Elec. Mfg. Electrical Manufacturing. 1250 6th Ave., New York 20, N.Y., M

Electronic & Radio Eng. Electronic & Radio Engineer, incorporating Wireless Engineer, Dorset House, Stamford St., London SE 1, England, M, $7.50

Electronic Des. Electronic Design, 19 E. 62 St., New York 21, N.Y., M

Electronic Eng. Electronic Engineering, 28 Essex St., Strand, London WC 2, England, M, $4

Electronic Ind. & Tele-Tech. Electronic Industries & Tele-Tech., 480 Lexington Ave., New York 17, N.Y., M, $5

Electronics, 330 W. 42 St., New York 36, N.Y., M, $6

Eng. J. Engineering Journal. Engineering Institute of Canada, 2050 Mansfield St., Montreal, Canada, M, $6

The Engr. The Engineer, 28 Essex St., London WC 2, England. W, £5

Engr. Dig. The Engineers' Digest, 120 Wigmore St., London W1, England, M, $7.50

Environmental Quart. Environmental Quarterly. Institute of Environmental Engineers, Inc., and Environmental Equipment Institute, Inc., 9 Spring St., Princeton, N.J., Q, $4

Ericsson Tech. Ericsson Technics. Telefonaktiebolaget L.M. Ericsson, Stockholm 32, Sweden, SA

Escher Wyss News. Escher Wyss Engineering Works Ltd., Zurich, Switzerland, Irreg.

Esso Air World. Esso Export Corp., 60 W. 49 St., New York 20, N.Y., BM

Esso Aviation News Digest. Esso Export Corp., 45 Rockefeller Plaza, New York 21, N.Y., W

FAI Bul. Fedération Aéronautique Internationale, Bulletin, 6, rue Galilée, Paris, France, Q

FAI Circ. Inf. Fedération Aéronautique Internationale, Circulaire d'Information, 6, rue Galilée, Paris, France, Irreg.

Fairey Rev. Fairey Review, Fairey Aviation Company, Ltd., 24 Bruton St., London W1, England, Q

Fasteners. Industrial Fasteners Institute, 1517 Terminal Tower, Cleveland 13, Ohio, Q

Der Flieger, Pettenkoferstr. 38, Munich, Germany, M, DM 18

Flight, Dorset House, Stamford St., London SE 1, England, W, $14

Flight Control. Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N.J., M

Flight Mag. Flight Magazine, 2700 N. Haskell, Dallas, Tex., M, $3

Flug-Revue, Paulinenstrasse 44, Stuttgart, Germany, M, DM 25.20

Flugwehr und -Technik, 16 Promenadenstrasse Frauenfeld, Switzerland, M, 13 Sw. fr.

Flugwelt, Bahnhofstr. 61, Wiesbaden, Germany, M, DM 21.60

Flying, 366 Madison Ave., New York 17, N.Y., M, $4

Flying Safety. USAF Office of Flying Safety. Superintendent of Documents, Washington 25, D.C., M, $3

Forschung Gebiete Ing., Ausg. A. Forschung auf dem Gebiete des Ingenieurwesens, Ausgabe A. Verein deutscher Ingenieure, Bongardstr. 3, Düsseldorf, Germany, BM, DM 51

Franklin Inst. J. Franklin Institute, Journal, Parkway at 20 St., Phila. 3, Pa., M, $10

The Frontier. Armour Research Foundation, Illinois Institute of Technology, Technology Center, Chicago 16, Ill., Q

Fusées et Recherche Aéronautique. Association pour l'Encouragement à la Recherche Aéronautique, 1 rue de Courty, Paris 7, France, Q, 5,500 fr.

G-E Rev. General Electric Review, General Electric Co., Schenectady 5, N.Y., BM

Gen. Radio Exper. General Radio Experimenter. General Radio Company, 275 Mass. Ave., Cambridge 39, Mass., M

GM Eng. J. General Motors Engineering Journal. General Motors Technical Center, P.O. Box 177, North End Station, Detroit 2, Mich., BM

Grazhdanskaia Aviatsiia. Glavnoe Upravlenie Grazhdanskogo Vozdushnogo Flota, Moscow, U.S.S.R., M

Handley-Page Bul. Handley-Page Bulletin. Handley-Page Ltd., London NW 2, England, Q

Hawker Siddeley Rev. Hawker Siddeley Review. Hawker Siddeley Group Ltd., 18 St. James's Square, London, SW 1, England, Q

Helicopter Assn. Gt. Brit. J. Helicopter Assn. of Gt. Britain, Journal, 4, The Sanctuary, Westminster, London SW 1, England, Q

Hokkaidô Gakugei U. J. Sect. B. Hokkaidô Gakugei University, Journal, Section B, Sapporo, Japan, Q

Holloman Mo. News Bul. Holloman Monthly News Bulletin, American Rocket Society, Inc., P.O. Box 807, Holloman AFB, New Mexico, M

Hunting Group Rev. Hunting Group Review, 4 Dunraven St., Park Lane, London W 1, England, Q

Hydraulic Engr. Hydraulic Engineer. Electrol Inc., 85 Grand St., Kingston, N.Y., BM

IATA Bul. IATA Bulletin. International Air Transport Assn., International Aviation Bldg., 1080 University St., Montreal 3, Canada, SA, $3.75

IBM J. Res. & Devel. IBM Journal of Research and Development. International Business Machines Corp., 590 Madison Ave., New York 22, N.Y., Q, $3.50

ICAO Bul. ICAO Bulletin. International Civil Aviation Organization, International Aviation Bldg., 1080 University St., Montreal 3, Canada, M, $2

IEE Proc. B. Institution of Electrical Engineers, Proceedings, Part B, Savoy Place, London WC 2, England, BM, £2 5s

IGY Ann. Annals of the International Geophysical Year, 122 East 55th St., New York 22, N.Y., Irreg., $17 per vol.

Ilmailu, Mannerheimintie 16-A, Helsinki, Finland, M, Fmk. 600

IME Proc. Institution of Mechanical Engineers, Proceedings, 1 Birdcage Walk, Westminster, London SW 1, England, Irreg.

Ind. & Eng. Chem. Industrial and Engineering Chemistry. American Chemical Society, 1155 16th St., NW, Washington 6, D.C., M, $4.50

Ind. Labs. Industrial Laboratories, 201 N. Wells St., Chicago 6, Ill., M

Ind. Quality Control. Industrial Quality Control. American Society for Quality Control, Inc., Room 6197, 161 W. Wisconsin Ave., Milwaukee 3, Wis., M, $9

Ind. Res. Newsletter. Industrial Research Newsletter. Armour Research Foundation Illinois Institute of Technology, Technology Center, Chicago 16, Ill., M

Ind. Sci. & Eng. Industrial Science and Engineering, 201 N. Wells St., Chicago 6, Ill., BM

Indian AF Quart. Indian Air Force Quarterly. Directorate of Training, Air HQ, New Delhi, India, Q

Indian Airman, Roy Mansions, Behala, Calcutta 34, India, M, 10 Rupees

Indian Inst. Sci. J. Indian Institute of Science, Journal, Bangalore 3, India, M, $6.50

Indian Skyways, Gandhigram Road, Juhu, Bombay 23, India, M, 20 Rupees

Info. & Control. Information and Control, 111 5th Ave., New York 3, N.Y., Q, $10

Informations Aéronautiques. Union Syndicale des Industries Aéronautiques, 4 rue Galilée, Paris 16, France, W

Ing. Aeronáutica. Ingeniería Aeronáutica. Asociación de Ingenieros Aeronáuticos, Arcipreste de Hita 14, Madrid, Spain, BM, 200 pesetas

Ing.-Arch. Ingenieur-Archiv. Neuenheimer Landstr. 24, Heidelberg, Germany, BM

Inst. Navigation J. Institute of Navigation, Journal, 1 Kensington Gore, London SW 7, England, Q, $6

Inst. Transp. J. Institute of Transport, Journal, 80 Portland Place, London W 1, England, BM, 21s.

Instrumentation. Industrial Division, Minneapolis-Honeywell Regulator Co., Wayne & Windrim Aves., Philadelphia 44, Pa., BM

Instruments and Automation, 1600 N. Main St., Pontiac, Ill., M, $4

Interavia, 6 Corraterie, Geneva, Switzerland, M, $7

IRE. Proc. Institute of Radio Engineers, Proceedings, 1 E. 79 St., New York 21, N.Y., M, $18

IRE Trans. Institute of Radio Engineers, Transactions, 2 E. 79th St., New York 21, N.Y.
- **ANE.** Aeronautical and Navigational Electronics, Q, $17
- **AP.** Antennas and Propagation, Q, $17
- **CS.** Communications Systems, Q, $17
- **EC.** Electronic Computers, Q, $17
- **TRC.** Telemetry & Remote Control, Q, $17

ISA J. Instrument Society of America, Journal, 1319 Allegheny Ave., Pittsburgh 33, Pa., M, $4

Istanbul Tek. U. Bul. Istanbul Teknik Üniversitesi, Bülteni, Istanbul, Turkey, Annually

Izmer. Tekh. Izmeritel'naia Tekhnika. Komitet Standartov, Mer i Izmeritel'nykh Priborov, Moscow, U.S.S.R., BM

J. Aero. Sci. Journal of the Aeronautical Sciences. Institute of the Aeronautical Sciences, Inc., 2 East 64th St., New York 21, N.Y., M, $15

J. Air Law & Commerce. Journal of Air Law & Commerce. Northwestern University, Chicago 11, Ill., Q, $6

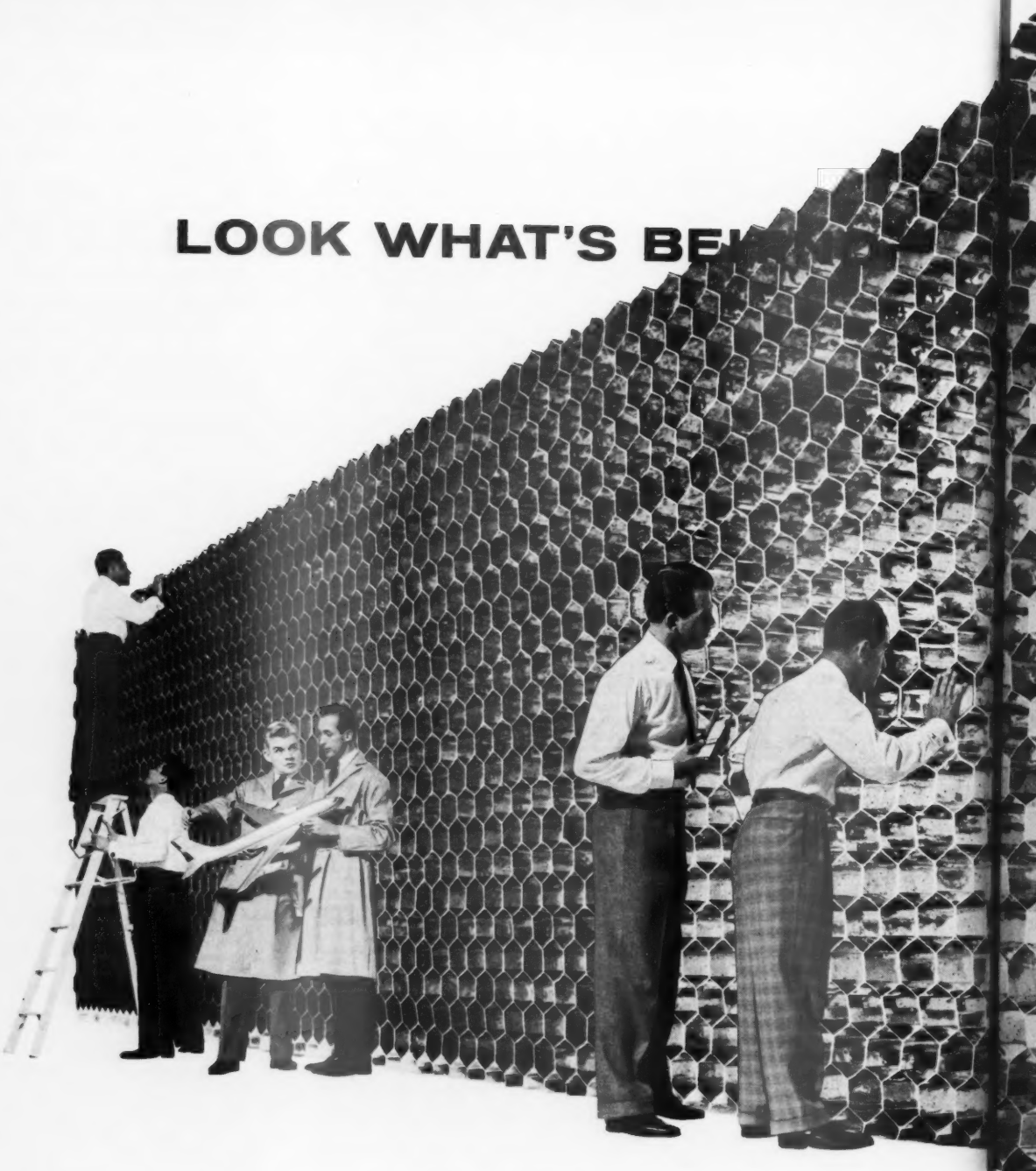
J. Air Traffic Control. Journal of Air Traffic Control, Air Traffic Control Association, 2030 North 16th St., Arlington 1, Va., Q, $5

J. Appl. Mech. Journal of Applied Mechanics. American Society of Mechanical Engineers, 29 W. 39 St., New York 18, N.Y., Q, $5

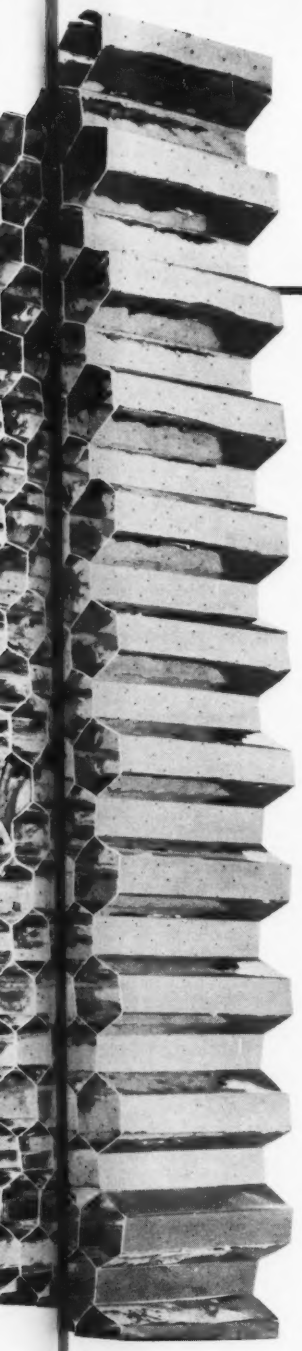
J. Appl. Phys. Journal of Applied Physics. American Institute of Physics, 57 E. 55 St., New York 22, N.Y., M, $12

J. Astron. Sci. Journal of the Astronautical Sciences, American Astronautical Society, 516 Fifth Ave., New York 36, N.Y., Q, $5

LOOK WHAT'S BE



XUM



HEXCEL HONEYCOMB

The No. 1 Technical Service Staff in the Industry:

Honeycomb experts—Hexcel Engineers—ready to solve your design and application problems wherever and whenever needed.

Research Staff and Facilities Unmatched by Any Other Honeycomb Manufacturer:

Men and equipment devoted to the problems of tomorrow, not the accomplishments of today.

Patented Processes and Machinery:

Special equipment and manufacturing know-how which have established Hexcel product superiority in the most demanding applications.

Largest Manufacturing Capacity of all Honeycomb Producers:

A "production line" source of supply for aluminum, stainless, glass fabric, cotton and paper honeycomb. Quality in Quantity.

HEXCEL—never content to be a "to spec" source... constantly probing in R&D and manufacturing. The result: Over 10 years of constant product improvement and technical help to honeycomb users.

HEXCEL® PRODUCTS INC.
World leader in honeycomb
Executive Offices: 2332 Fourth Street, Berkeley 10, Calif.
Plants: Oakland and Berkeley, Calif.; Havre de Grace, Md.
Sales Offices: Long Island City, N.Y.; Fort Worth, Texas; Inglewood, Calif.

Technical Service Bulletins containing Honeycomb basic data are mailed periodically. If you are not now receiving them, please write Department LA 11 at Hexcel executive offices.

5106

XUM

J. Atmos. & Terrestrial Phys. Journal of Atmospheric and Terrestrial Physics, 4 Fitzroy Square, London W1, England; 122 E. 55th St., New York 22, N.Y., BM, $14

J. Av. Med. Journal of Aviation Medicine. Aero Medical Assn., 2642 University Ave., St. Paul 14, Minn., BM, $7.50

J. Eng. Educ. Journal of Engineering Education. American Society for Engineering Education, University of Illinois, Urbana, Ill., M, $6

J. Fluid Mech. Journal of Fluid Mechanics, Taylor & Francis Ltd., Red Lion Court, Fleet St., London EC 4, England; Cambridge University Press, 32 East 57th St., New York 22, N.Y., BM, £5. 10s., $18.50

J. Math. & Mech. Journal of Mathematics & Mechanics. Graduate Institute for Applied Mathematics, University of Indiana, Bloomington, Ind., BM, $18

J. Math. & Phys. Journal of Mathematics and Physics. MIT, Cambridge 39, Mass., Q, $6

J. Mech. & Phys. Solids. Journal of the Mechanics and Physics of Solids, 4 Fitzroy Square, London W 1, England; 122 E. 55th St., New York 22, N.Y., Q, $12.60

J. Meteorology. Journal of Meteorology. American Meteorological Society, 3 Joy St., Boston 8, Mass., BM, $9.50

J. Res. Journal of Research. U.S. National Bureau of Standards. Supt. of Documents, Washington 25, D.C., M, $4

J. Sci. & Ind. Res. Journal of Scientific & Industrial Research. Council of Scientific & Industrial Research, 20 Pusa Road, New Delhi 5, India, 15 Rupees

J. Sci. Instr. Journal of Scientific Instruments. Institute of Physics, 47 Belgrave Square, London SW 1, England, M, £5

J. Tech. Journal of Technology, Bengal Engineering College, Superintendent—Govt. Printing, Calcutta. India, SA, $2.50

Japan Soc. Aero. Eng. J. Japan Society of Aeronautical Engineering, Journal, Kikokwan No. 3, 1-chome, Shiba-Tamura-cho, Minato-ku, Tokyo, Japan, M

Japan Soc. Mech. Eng. Bul. Japan Society of Mechanical Engineers, Bulletin, 2-chome Marunouchi, Chiyoda-ku, Tokyo, Japan, BA

Jemná Mech. & Optika. Jemná Mechanika a Optika, Spálená ulice č. 51, Prague 2, Czechoslovakia, M, 60 kčs.

Jet Propulsion. American Rocket Society, 500 Fifth Avenue, New York 36, N.Y., M, $12.50

Joint Services Recognition Journal. Air Ministry, Richmond Terrace. Whitehall, London SW 1, England, M

Kryl'ia Rodiny. DOSAAF, Novo-Rianzanskaia 26, Moscow, USSR, M

KTH Handlingar. Kungl. Tekniska Högskolans, Handlingar, Stockholm 70, Sweden, Irreg.

Kyushu U., Rep. Res. Inst. Appl. Mech. Kyushu University, Research Institute for Applied Mechanics, Reports, Fukuoka, Japan, SA

Light Metals, Bowling Green Lane, London EC 1, England, M, 26s.

Lockheed Field Serv. Dig. Lockheed Field Service Digest. Lockheed Aircraft Corp., Burbank, Calif., BM

The Log. British Air Line Pilots Assn., 95 Mount St., London W 1, England, M

Lond. Math. Soc. Proc. London Mathematical Society, Proceedings, Amen House, London EC 4, England, Q, £4

Lubrication. The Texas Co., 135 E. 42nd St., New York 17, N.Y., M

Lubrication Eng. Lubrication Engineering. American Society of Lubrication Engineers, 84 E. Randolph St., Chicago 1, Ill., M, $6

Luftfahrttechnik. Verein deutscher Ingenieure, Bongardstr. 3, Düsseldorf, Germany, M, DM 43.50

Mach. Des. Machine Design, Cleveland 13, Ohio, BW, $10

Mag. of Magnesium. Magazine of Magnesium. Brooks & Perkins, Inc., 1950 Fort St., Detroit 16, Mich., Q

Mag. of Standards. Magazine of Standards. American Standards Assn., Inc., 70 E. 45 St., New York 17, N.Y., M, $7

Marconi Rev. The Marconi Review. Marconi's Wireless Telegraph Co. Ltd., Chelmsford, England, Q

Materials in Des. Eng. Materials in Design Engineering, 430 Park Ave., New York 22, N.Y., M, $3

Math. Tables Aids to Comp. Mathematical Tables and Other Aids to Computation. National Academy of Sciences—National Research Council, 2101 Constitution Ave., Washington, D.C., Q, $5

MATS Flyer. Military Air Transport Service. Supt. of Documents, Washington 25, D.C., M, $2.25.

Mech. Eng. Mechanical Engineering. American Society of Mechanical Engineers, 29 W. 39 St., New York 18, N.Y., M, $7

Metal Treat. Metal Treatment and Drop Forging, 17–19 John Adam St., Adelphi, London WC 2, England, M, 30s.

Metallurgia, 31 King St. W., Manchester 3, England, M, 24s.

Meteor. Abs. & Bibliog. Meteorological Abstracts and Bibliography. American Meteorological Society, 3 Joy St., Boston 8, Mass., M, $8

Meteorological Mag. The Meteorological Magazine. Air Ministry Meteorological Office. British Information Services, 45 Rockefeller Plaza, New York 20, N.Y., M, $4

Mil. Electronics. Military Electronics, 2775 S. Moreland Blvd., Cleveland 20, Ohio, M, $9

Mil. Med. Military Medicine. Assn. of Military Surgeons, 1726 Eye Street, NW, Washington, D.C., M, $7.50

Military Aircraft Data Sheets. Aviation Studies (International) Ltd., 29–31 Cheval Place, Knightsbridge, London SW 7, England, Q, £2

Missiles & Rockets, 1001 Vermont Avenue, NW, Washington 5, D.C., M, $8

Missile Des. & Devel. Missile Design & Development, 140 E. 40th St., New York 16, N. Y., M, $10

Mo. Weather Rev. Monthly Weather Review. U.S. Weather Bureau. Supt. of Documents, Washington 25, D.C., M, $3

Nav. Res. Logistics Quart. Naval Research Logistics Quarterly. Office of Naval Research. Superintendent of Documents, Washington 25, D.C., Q, $1.50

Naval Av. News. Naval Aviation News. Chief of Naval Operations and Bureau of Aeronautics. Superintendent of Documents, Washington 25, D.C., M, $2

Navigation. Institut Français de Navigation, 13 rue de l'Université, Paris 7, France, Q, 2,500 fr.

Navigation. Institute of Navigation, University of California, 405 Hilgard Ave., Los Angeles 24, Calif., Q, $10

News Report, National Academy of Sciences. National Research Council, 2101 Constitution Ave., Washington 25, D.C., BM, $2

Nihon U. Res. Inst. Tech. J. Nihon University, Research Institute of Technology, Journal, No. 8, 1-chome, Surugadai, Kanda, Chiyoda-ku, Tokyo, Japan, Irreg.

Noise Control. Acoustical Society of America, 57 East 55 St., New York 22, N.Y., BM, $8

Notiz. Av. Notiziario de Aviazione. Ufficio del Segretario Generale, Ministero della Difesa—Aeronautica, Rome, Italy, M

Nuclear Eng. Nuclear Engineering, Bowling Green Lane, London EC 1, England, M, $7

Nucleonics, 330 W. 42nd St., New York 36, N.Y., M, $8

Official Air Line Guide, 1001 Vermont Ave., NW, Washington 5, D.C., M, $13.50

Oper. Res. Operations Research, Operations Research Society of America, Mt. Royal & Guilford Aves., Baltimore 2, Md., BM, $7.50

Ordnance. American Ordnance Assn., 708 Mills Bldg., Washington 6, D.C., BM, $4.50

OSA J. Optical Society of America, Journal, 334 E. 45th St., New York 17, N. Y., M, $8.50

Pacific J. Math. Pacific Journal of Mathematics. Univ. of California Press, Berkeley 4, Calif., Q, $12

Papers in Meteorology & Geophys. Papers in Meteorology and Geophysics. Meteorological Research Institute, Mabashi, Suginami, Tokyo, Japan, Irreg.

Periodica Polytech., Eng. Periodica Polytechnica, Engineering, Postafiók 440, Budapest 62, Hungary, Q, $4

Periodica Polytech., Chem. Periodica Polytechnica, Chemical Engineering, Postfiók 440, Budapest 62, Hungary, Q, $4

Periodica Polytech., El. Periodica Polytechnica, Electrical Engineering, Postfiók 440, Budapest 62, Hungary, Q, $4

Philips Tech. Rev. Philips Technical Review. N.V. Philips Co., Eindhoven, Netherlands, M, $5

Philos. Mag. The Philosophical Magazine, Red Lion Court, Fleet St., London EC 4, England, M, £8

Photogrammetric Eng. Photogrammetric Engineering, American Society of Photogrammetry, 1515 Massachusetts Ave., NW, Washington 5, D.C., 5 issues per year, $6

Photographic Sci. & Engrg. Photographic Science and Engineering, Society of Photographic Scientists and Engineers, Box 1609, Main Post Office, Washington, D.C., Q, $8

Phys. Fluids. The Physics of Fluids, American Institute of Physics, 335 East 45th St., New York 17, N.Y., BM, $10

Phys. Soc. Japan J. Physical Society of Japan, Journal, Dept. of Physics, Faculty of Science, University of Tokyo, Bunkyo-ku, Tokyo, Japan, M, $5

Planes. Aircraft Industries Assn. of America, 610 Shoreham Bldg., Washington 5, D.C., M

Pol. Inst. Lot. Prace. Poland, Instytut Lotnictwa, Prace. Ministerstwo Przemysu Maszynowego, Warsaw, Poland, Irreg.

Prikl. Mat. i Mekh. Prikladnaia Matematika i Mekhanika, Akademiia Nauk SSSR, Moscow, USSR, BM

Prod. Eng. Product Engineering, 330 W. 42 St., New York 36, N.Y., W, $5

Project Engr. Project Engineer. The Thermix Corp., Greenwich, Conn., M

Propel, Mariagervej 4, Helsingor, Denmark, M

Protar, Solothurn, Switzerland, BM, 15 Sw. fr.

Quart. Appl. Math. Quarterly of Applied Mathematics. Brown University, Providence 12, R.I., Q, $6

Quart. J. Mech. & Appl. Math. Quarterly Journal of Mechanics and Applied Mathematics, Amen House, London EC 4, England, Q, 60s.

Radio, 26 Novo-Riazanskaia yl., Moscow B-66, U.S.S.R., M

RCA Rev. RCA Review. RCA Laboratories, Radio Corporation of America, Princeton, N.J., Q, $2

RAeS J. Royal Aeronautical Society, Journal, 4 Hamilton Place, London W 1, England, M, £ 10s. 6d.

Raketentech. & Raumfahrtforsch. Raketentechnik und Raumfahrtforschung. Deutsche Gesellschaft für Raketentechnik und Raumfahrt, Neuensteiner Strasse 19, Stuttgart-Zuffenhausen, Germany, Irreg., $1 per issue

Rec. Ocean. Works Japan. Records of Oceanographic Works in Japan. Japanese National Commission for UNESCO, 4-3 Kasumigasiki, Chiyoda-ku, Tokyo, Japan, Irreg.

La Recherche Aéronautique. Office National d'Etudes et de Recherches Aéronautiques (ONERA), 29 ave. de la Division-Leclerc, Chatillon-sous-Bagneux (Seine), France, BM, 4,300 fr.

Repülés, Engels tér 14, Budapest 5, Hungary, M, 48 ft.

Res. Rev. Research Reviews. Office of Naval Research, Department of the Navy. Supt. of Documents, Washington 25, D.C., M, $1.50

Res. Trends. Research Trends. Cornell Aeronautical Laboratory, Inc., 4455 Genessee St., Buffalo 21, N.Y., Q

Rev. Aero. Revista de Aeronáutica. Ministro del Aire, 8 Romero Robledo, Madrid, Spain, M, 90 pesetas

Rev. Cienc. Apl. Revista de Ciencia Aplicada, Serrano 150, Madrid, Spain, BM, 125 pesetas

Rev. Math. Pures & Appl. Revue de Mathématiques Pures et Appliquées. Académie de la Republique Populaire Roumaine, 125, Calea Victoriei, Bucarest, Rumania, Irreg.

Rev. Méc. Appl. Revue de Méchanique Appliquée. Institut de Mécanique Appliquée, Académie de la Republique Populaire Roumaine, 15 rue C. Mille. Bucarest, Rumania, Irreg.

Rev. Nac. Aero. Revista Nacional de Aeronáutica, 741 Ave. Cordoba, Buenos Aires, Argentina, M, $6

Rev. Phys. Revue de Physique, Academia Republicii Populare Romine, Bucarest, Rumania, Irreg.

Rev. Sci. Instr. Review of Scientific Instruments. American Institute of Physics, 57 E. 55 St., New York 22, N.Y., M, $9

Rev. Sci. Tech. Revue des Sciences Techniques. Académie de la Republique Populaire Roumaine, 125, Calea Victoriei, Bucarest, Rumania, Irreg.

Rev. Transp. Revista Transporturilor, Str. Ioan Ghica 3, Bucarest, Rumania, M, lei 30

Riv. Aero. Rivista Aeronautica. Ministero Difesa—Aeronautica, viale dell'Universitá 4, Rome, Italy, M, $7

Riv. Med. Aero. Rivista di Medicina Aeronautica, via P. Gobetti 2, Rome, Italy, Q, L. 3,600

Riv. Meteorologia Aero. Rivista di Meteorologia Aeronautica. Servizio Meteorologico d'Aeronautica, via San Vincenzo di Paoli 11, Rome, Italy, Q, L. 3,000

Royal Soc. Edin. Proc. A. Royal Society of Edinburgh, Proceedings, Section A, Mathematical and Physical Sciences, 22 George St., Edinburgh 2, Scotland, Irreg.

Royal Soc. (London) Philos. Trans. Ser. A. Royal Society (London), Philosophical Transactions, Series A, Mathematical and Physical Sciences, Burlington House, Piccadilly, London W 1, England, Irreg., £9 9s.

Royal Soc. (London) Proc. Ser. A. Royal Society (London), Proceedings, Series A, Mathematical and Physical Sciences, Burlington House, Piccadilly, London W 1, England, Irreg.

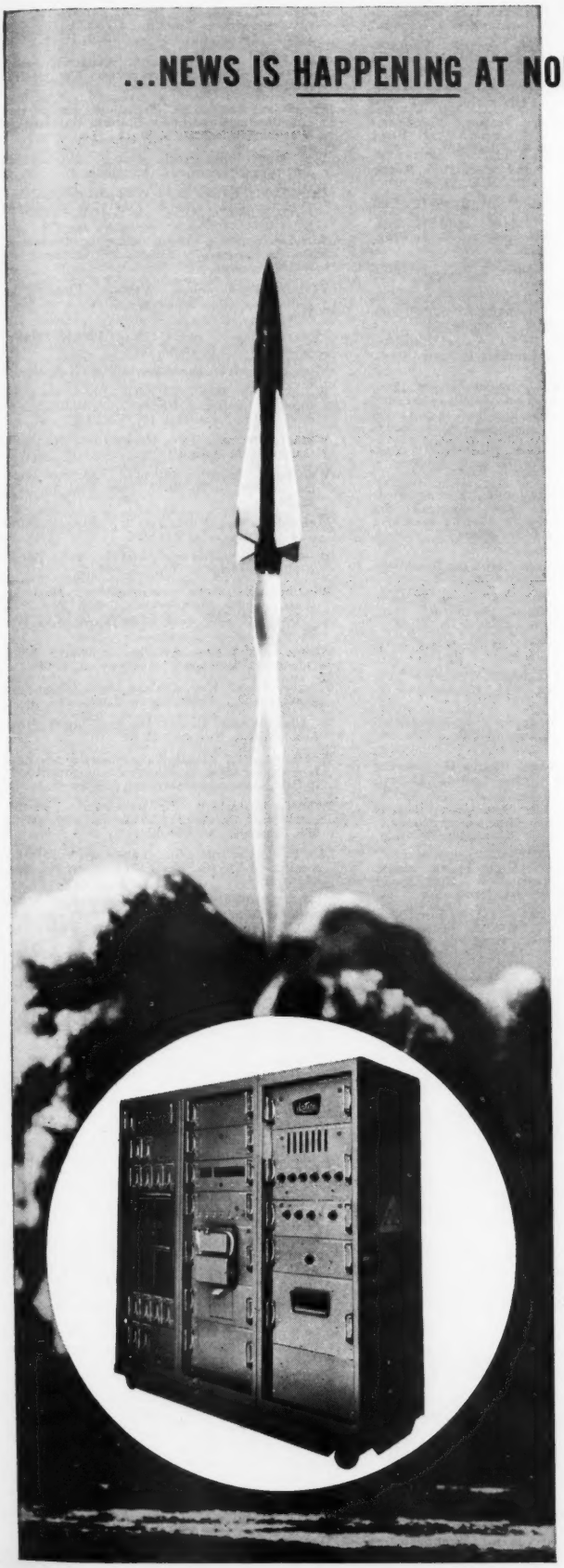
Rozprawy Inzynierskie. Polska Akademia Nauk, ul. Nowy Swiat 72, Warsaw, Poland, Q, 80 zl.

Ryan Reporter. Ryan Aeronautical Co., P.O. Box 311, San Diego 12, Calif.

Saab Sonics. Saab Aircraft Co., Linköping, Sweden, Irreg.

XUM

...NEWS IS HAPPENING AT NORTHROP



OPERATIONAL NOW!
NORTRONICS UNIVERSAL DATICO
TO CHECK OUT
ADVANCED MISSILE SYSTEMS!

READY NOW! The first and only universal automatic checkout equipment in production is Nortronics' Universal Datico. Standardized, self-checking test equipment, readily adaptable to any missile system or group of systems, Universal Datico is a single system of automatic evaluation equipment available for support of advanced operational missiles. Other production contracts include checkout applications to U.H.F. equipment and autopilot sub-systems.

PERFORMANCE PROVED. Datico has logged thousands of hours of reliable performance during which its speed and adaptability from one system to another have been demonstrated. Its rapid, unerring, Hi-Go-Lo evaluation of existing systems indicates its applicability to future systems as well as to today's. It quickly locates malfunction of the system or any sub-system element down to piece parts and records its findings on printed tape.

TIME–MANPOWER–DOLLARS. Datico saves all three. No need for costly, time-consuming research and development. Datico is available now for today's requirements. Application of Datico to your problem can mean savings up to 75% in manpower plus a dividend in reduced skill-levels required; savings up to 90% in checkout time; and 50% in acquisition cost.

TOMORROW'S DATICOS – Nortronics' continuing development program, combined with the management and engineering foresight which created Datico in time for today's weapons, is now developing advanced Daticos for tomorrow's weapons. These new checkout devices will incorporate even greater speed and such features as evaluation of total system degradation without sacrificing reliability and relative simplicity.

If you have a checkout problem...if you have checkout requirements for any system or level of a system, call Nortronics today, or write Chief Applications Engineer, Dept. 2003-J Nortronics, A Division of Northrop Aircraft, Inc., 500 East Orangethorpe, Anaheim, California.

NORTRONICS
A Division of Northrop Aircraft, Inc.

SAE J. Society of Automotive Engineers, Journal, 485 Lex. Ave., New York 17, N.Y., M, $10

Saro Prog. Saro Progress. Saunders-Roe Ltd., East Cowes, Isle of Wight, England, Q

SBAC Press Summary. Society of British Aircraft Constructors, 29 King St., St. James's, London SW 1, England, W

Schw. Aero-Rev. Schweizer Aero-Revue, Aero-Club der Schweiz, Hirschengraben 22, Zurich, Switzerland, M, 18 Sw. fr.

Science. American Assn. for the Advancement of Science, 1515 Mass. Ave., NW, Washington 5, D.C., W, $7.50

Science Record. Science Press, 38 Suchou Hutung, Peking, China, Irreg.

Scientia Sinica. Academia Sinica, 38 Suchou Hutung, Peking, China, Irreg.

Shell Av. News. Shell Aviation News. Aviation Dept., Shell Oil Co., 50 W. 50 St., New York 20, N.Y., M

Shorts Quart. Rev. Shorts Quarterly Review. Short Brothers & Harland Ltd., Queen's Island, Belfast, Ireland, Q

Sky & Tel. Sky & Telescope, Harvard College Observatory, 60 Garden St., Cambridge 38, Mass., M, $5

Skyline. North American Aviation, Inc., International Airport, Los Angeles 45, Calif., Q

Skyways, 122 E. 42 St., New York, N.Y., M, $4

SLAE J. Society of Licensed Aircraft Engineers, Journal (incorporating The Technical Instructor), 1 High St., Maidenhead, Berkshire, England, M, 30s.

Soaring. Soaring Society of America and the Soaring Assn. of Canada, P.O. Box 71, Elmira, N.Y.; Ferguson Rd., Dallas 28, Tex., BM, $4

Soc. Ingr. Civils de France Bul. Société des Ingénieurs Civils de France, Bulletin, 19 rue Blanche, Paris 9, France, SM, 3,000 fr.

Soc. Ingr. Civils de France Mém. Société des Ingénieurs Civils de France, Mémoires, 19 rue Blanche, Paris 9, France, BM, 2,800 fr.

Soc. Inst. Tech. Trans. Society of Instrument Technology, Transactions, 4, Grosvenor Gardens, London SW 1, England, Q, £2 10s.

Solar Quart. Solar Quarterly, Solar Aircraft Company, San Diego 12, Calif., Q

Sov. Phys.—Acous. Soviet Physics—Acoustics, American Institute of Physics, 57 E. 55 St. New York 22, N.Y., Q, $20

Sov. Phys.—Dokl. Soviet Physics—Doklady (Physics Section), American Institute of Physics, 57 E. 55 St., New York 22, N.Y., BM, $25

Sov. Phys.—JETP. Soviet Physics—JETP (Journal of Experimental and Theoretical Physics), American Institute of Physics, 57 E. 55 St., New York 22, N.Y., M, $64

Sov. Phys.—Tech. Phys. Soviet Physics—Technical Physics, American Institute of Physics, 57 E. 55 St., New York 22, N.Y., M, $90

Space J. Space Journal, Box 94, Nashville, Tennessee, Q, $2

Space Tech. Space Technology, 330 West 42nd Street, New York 36, N.Y., Q, $3

Spaceflight. British Interplanetary Society, 12 Bessborough Gardens, London SW 1, England, Q

SPE J. Society of Plastic Engineers, Journal, 35 East Putnam Ave., Greenwich, Conn., M, $4

Sperry Eng. Rev. Sperry Engineering Review, Sperry Gyroscope Co., Great Neck, N.Y., BM

Sperry Rev. The Sperry Review. The Sperry Gyroscope Co., Ltd., Great West Road, Brentford, Middlesex, England, SA

Sperryscope. Sperry Rand Corp., 30 Rockefeller Plaza New York 20, N.Y., Q

SRI J. Stanford Research Institute, Journal, Menlo Park, Calif., Q, $4

Steel Processing & Conversion, 624 Grant Bldg., Pittsburgh 30, Pa., M, $2.50

Strojniski Vestnik. Aškerčeva 28, Ljubljana, Yugoslavia, Q, 520 din.

Stud. Cerc. Mec. Aplic. Studii si Cercetari de Mecanica Aplicata. Academia Republicii Populare Romine, Bucarest, Rumania, Q

Stud. Cerc. Stiint. Studii si Cercetari Stiintifice. Academia Republicii Populare Romine, Bucarest, Rumania, Q

Sylvania Technologist. Sylvania Electric Products, Inc., Bayside, N.Y., Q, $1.50

Taylor Tech. Taylor Technology. Taylor Instrument Companies, Rochester 1, N.Y., Q

Tec. Ital. Technica Italiana. Consiglio Nazionale delle Ricerche, via Beccaria 6, Trieste, Italy, M, L. 6,000

Tech. et Sci. Aéronautiques. Technique et Science Aéronautiques. Assn. Française des Ingénieurs et Techniciens de l'Aéronautique (AFITA), 6 rue Cimarosa, Paris 16, France, BM

Tech. Lotnicza. Technika Lotnicza, Nowowiejska 24, Warsaw 10, Poland, BM, 54 zl.

Tech. News Bull. Technical News Bulletin. U.S. National Bureau of Standards. Supt. of Documents, Washington 25, D.C., M, $1

Tech. Rev. The Technology Review. MIT, Cambridge 39, Mass., M, $4

Tek. Tidsk. Teknisk Tidskrift. Svenska Teknologföreningen, Box 841, Stockholm 1, Sweden, W, 50 kr.

Teploenergetika. Ministerstvo Elektrostantsii SSSR—Akademiia Nauk SSSR, Moscow, USSR, M

Tex. Eng. Exp. Sta. News. Texas Engineering Experiment Station News, College Station, Tex., Q

Thompson Prod. Eng. Bul. Thompson Products Engineering Bulletin. Thompson Products, Inc., 23555 Euclid Ave., Cleveland 17, Ohio, Irreg.

Tôhoku U. Rep. Inst. High Speed Mech. Tôhoku University, Institute of High Speed Mechanics, Reports, Sendai, Japan

Tokyo Inst. Tech., Bul., Ser. A. Tokyo Institute of Technology, Bulletin, Series A, Oh-Okayma, Meguro-ku, Tokyo, Japan, Irreg.

Tokyo Inst. Tech., Bul., Ser. B. Tokyo Institute of Technology, Bulletin, Series B, Oh-Okayama, Meguro-ku, Tokyo, Japan, Irreg.

Tool Engr. Tool Engineer. American Society of Tool Engineers, 10700 Puritan Ave., Detroit 38, Mich., M, $6

Trend in Eng. The Trend in Engineering. Engineering Experiment Station, University of Washington, Seattle 5, Wash., Q

U.S. Nav. Inst. Proc. United States Naval Institute, Proceedings, Annapolis, Md., M, $3

Uspekhi Fiz. Nauk. Uspekhi Fizicheskikh Nauk, Fizmatgiz, 15 Leninskii Prospekt, Moscow B-71, U.S.S.R., M

VDI-Zeitschrift. Verein deutscher Ingenieure, Bongardstrasse 3, Düsseldorf, Germany, 36 issues per pear, DM 80

Vestnik Vozd. Flota. Vestnik Vozdushnogo Flota, 23 B. Pirogovskaia, Moscow G-48, U.S.S.R., M

Vickers Mag. Vickers, Ltd., Vickers House, London SW 1, England, SA

Vitesse-Speed, 28, rue Vaneau, Paris 7, France, M

W. U. Tech. Rev. Western Union Technical Review. Western Union Telegraph Co., 60 Hudson St., New York 13, N.Y., Q, $1.50

Wasserwirtschaft, Pfizerstrasse 5-7, Stuttgart, Germany, M, DM 30

Welding J. Welding Journal. American Welding Society, 33 W. 39 St., New York 18, N.Y., M, $7

Weltraumfahrt, Stuttgarterstr. 20, Frankfurt a.M., Germany, Q, DM 9.84

Western Av. Western Aviation, 4328 Sunset Blvd., Los Angeles 29, Calif., M, $3

Westinghouse Engr. Westinghouse Engineer. Westinghouse Electric Corp., P.O. Box 2278, 3 Gateway Center, Pittsburgh 30, Pa., BM, $2.50

Whites Av. Whites Aviation, Dilworth Bldg., Queen St., Auckland, New Zealand, M, $3

Wings. Royal New Zealand Aero Club, Inc., 1 Marion St., Wellington, N.Z., M, 15s.

Wireless World, Dorset House, Stamford St., London SE 1, England, M, $5

WMO Bul. WMO Bulletin. World Meteorological Organization, Campagne Rigot, ave. de la Paix, Geneva, Switzerland, Q, 4 Sw. fr.

ZAMM. Zeitschrift für angewandte Mathematik und Mechanik, Mohrenstr. 39, Berlin W8, Germany, M, DM 60

ZAMP. Zeitschrift für angewandte Mathematik und Physik, Basel 10, Switzerland, BM, 48 Sw. fr.

ZFW. Zeitschrift für Flugwissenschaften. Wissenschaftliche Gesellschaft für Luftfahrt e.V. (WGL), Burgplatz 1, Braunschweig, Germany, M, DM 48

Acoustics, Sound, Noise

Bibliography on Aircraft Noise. *Netherlands TDCK Rep. 15350,* Sept., 1958. 69 pp. 238 refs.

Vozbuzhdenie, Otrazhenie i Izluchenie Poverkhnostnykh Voln na Kline s Zadannymi Impedantsami Granei. G. D. Maliuzhinets. *AN SSSR Dokl.,* July 21, 1958, pp. 436–439. In Russian. Investigation of the excitation, reflection, and radiation of surface waves in a wedge-like region with given face impedances.

Aerodynamics, Fluid Mechanics

Aerothermodynamics

Travaux de la Commission d'Aérodynamique de l'A.F.I.T.A.—L'échauffement Aérodynamique; Exposés Théoriques. M. Brun. *Tech. & Sci. Aéronautiques,* Feb., 1958, pp. 1–12. In French. Survey of the fundamental problems of aerodynamic heating, including an analysis based on two cases: (a) aerodynamic heating of a fluid jet by compression and friction; (b) thermal exchange between a stream of air and an adiabatic plate. Also included is an analysis of the effect of structural heating on aircraft design.

Flat Plate Laminar Skin Friction and Heat Transfer in the Free Molecule to Continuum Flow Regimes. Harold Mirels. *Jet Propulsion,* Oct., 1958, pp. 689, 690. Presentation of a proposal to use the solution of Rayleigh's problem by continuum equations with slip boundary conditions as a model to show the functional dependence of wall shear and heat transfer on Mach Number and Reynolds Number in the free molecule to continuum regimes.

Approximate Method for Calculation of Laminar Boundary Layer with Heat Transfer on a Cone at Large Angle of Attack in Supersonic Flow. W. E. Brunk. *U.S., NACA TN 4380,* Sept., 1958. 26 pp. Reduction of the laminar boundary-layer equations on the windward generator of the plane of symmetry to a set of simultaneous algebraic equations by means of an integral technique.

Turbulent Heat Transfer Through a Highly Cooled, Partially Dissociated Boundary Layer. P. H. Rose, R. F. Probstein, and M. C. Adams. (*Avco Res. Lab. RR 14,* Jan., 1958.) *J. Aero/Space Sci.,* Dec., 1958, pp. 751–760. 16 refs. Analytical and experimental investigation in which heat transfer data obtained in shock tubes are presented and correlated by a semiempirical theory which includes the effect of atomic diffusion.

Heat Transfer to a Sphere at the Transition from Free Molecule Flow. P. Hammerling and B. Kivel. *Phys. Fluids,* July-Aug., 1958, pp. 357, 358. USAF-supported presentation of an equation for total energy per unit time given to a sphere.

Boundary Layer

Effect of Boundary Layer Thickness on Flutter of Control Surfaces; A Brief Survey of Relevant Reports. N. C. Lambourne. (*NATO AGARD 7th Structures & Materials Panel, Rome, Mar. 24–Apr. 3, 1958.*) *NATO AGARD Rep. 183,* Mar.–Apr., 1958. 2 pp. 11 refs.

Boundary-Layer Transition with Gas Injection. C. J. Scott and G. E. Anderson. *J. Aero/Space Sci.,* Dec., 1958. p. 791. Description of exploratory studies conducted to ascertain the effects of gas injection on the stability of the laminar boundary layer over a conical surface.

A Low-Speed Experimental Investigation of the Effect of a Sandpaper Type of Roughness on Boundary-Layer Transition. A. A. von Doenhoff and E. A. Horton. *U.S., NACA Rep. 1349,* 1958. 16 pp. 15 refs. Supt. of Doc., Wash., $0.25.

Transition from Laminar to Turbulent Shear Flow—A Review of Some Recent Advances in Its Understanding. M. V. Morkovin. (*ASME Annual Meeting, New York, Dec. 1–6, 1957.*) *ASME Trans.,* July, 1958, pp. 1,121–1,128. 46 refs. AFOSR-supported research.

Razvitie Laminarnogo Pogranichnogo Sloia na Plastinke, Privedennoi Impul'sivno v Dvizhenie. L. A. Rozin. *Prikl. Mat. i Mekh.,* May-June, 1958, pp. 407–412. In Russian. Study of the laminar boundary layer in the case of a semi-infinite flat plate moving in an incompressible viscous liquid.

The Turbulent Boundary Layer on a Rough Curvilinear Surface. V. F. Droblenkov. (*AN SSSR Otd. Tekh. Nauk Izv.,* No. 8, 1955, pp. 17–21.) *U.S., NACA TM 1440,* Sept., 1958. 10 pp. Translation. Derivation of a method for the calculation of the turbulent boundary-layer skin-friction drag on a flat plate or a curvilinear surface having a pressure gradient, and with or without distributed roughness.

Control Surfaces

Large-Scale Wind-Tunnel Tests of a Jet-Transport-Type Model with Leading- and Trailing-Edge High-Lift Devices. D. H. Hickey and Kiyoshi Aoyagi. *U.S., NACA RM A58H12,* Sept. 26, 1958. 32 pp. Presentation of three-component longitudinal data for several leading edge configurations studied in conjunction with double slotted trailing-edge flaps.

Flow of Fluids

D—Strömungslehre. (*GAMM Wissenschaftliche Tagung, Saarbrücken, Apr. 8–12, 1958.*)

ZAMM, July-Aug., 1958, pp. 307–333. 45 refs. In German and English. *Partial Contents:* Berechnung der Strömung in radialen Laufrädern, W. Albring. Über die Darstellung von Körpern in Potentialströmung, K. Eggers. Die Totalreflexion von kugelförmigen Kompressionsfronten in elastischen Medien; v. Schmidtsche Kopfwellen, K. Hasselmann. On the Stability of Flow in the Boundary Layer Near the Nose of Blunt Body, A. M. Kuethe. Abschätzung des Regularitätsgebietes und numerische Darstellung transsonischer Düsenströmungen, E. Martensen. Zur Abschätzung der Propellereigenschaften bei höheren Unterschallgeschwindigkeiten, Svetopolk Pivko. Turbulente Reibung und Ablösung in ebener Quellströmung, N. Scholz. Zur Stabilität der Couette-Strömung, F. Schultz-Grunow. Approximate Analysis of Non-Linear Flutter Systems, S. F. Shen. Über geordnete und ungeordnete natürliche Bewegungen und ihre Deutung, H. St. Stefaniak. Ein neues Charakteristikenverfahren für instationäre Strömungen und seine Anwendungen, I. Teipel. Symposium of papers covering: the calculation of flow in radial rotors, bodies in potential flow, stability of flow in the boundary layer near the nose of a blunt body, calculation of the transonic nozzle flow, determination of propeller characteristics for high subsonic velocities, turbulent friction and separation in plane source flows, stability of the Couette flow, approximate analysis of nonlinear flutter systems, study of laminar and turbulent flow, and method of characteristics for nonstationary flow and its application.

Some Methods of Evaluating Imperfect Gas Effects in Aerodynamic Problems. G. A. Bird. *Gt. Brit., ARC CP 397* (Jan., 1957) 1958. 32 pp. BIS, New York, $0.81.

Predel'nye Avtomodel'nye Odnomernye Neustanovivshiesia Dvizheniia Gaza (Zadacha Koshii Zadacha o Porshne). S. S. Grigorian. *Prikl. Mat. i Mekh.*, May-June, 1958, pp. 301–310. In Russian. Evaluation of Cauchy's problem in the qualitative investigation of the nonsteady motion of an ideal nonheatconducting gas.

Progrès Récents de la Mécanique des Fluides Transsonique et Supersonique Intéressant l'Aviation et les Turbomachines. Robert Legendre. *Tech. & Sci. Aéronautiques*, Feb., 1958, pp. 13–23. In French. Survey of progress in transonic and supersonic mechanics of fluids, including hydraulic analogies, propagation of shock waves, laws of similarity and the area rule, calculation of blade profiles, and techniques for three-dimensional visualization.

Relaxation Lags in Gas Flow. Henry Aroeste and Morton Rudin. *Jet Propulsion*, Oct., 1958, pp. 690, 691. Discussion of methods to estimate lags in flow with consequent determination of the approach to equilibrium.

Note on Diffusive Separation of Gas Mixtures in Flow Fields. V. C. Liu. *J. Appl. Phys.*, Aug., 1958, pp. 1,188, 1,189. Discussion of the effect of pressure-diffusion flux upon the concentration distribution of gas mixtures in flow fields. The equation of concentration is formulated for a binary gas mixture in which the mass ratio is large and the concentration of the lighter gas is very small.

Über die strenge Lösung der Navier-Stokes-Gleichungen bei einer Quellstrecke im Halbraum. G. Paskalew and I. Tschobanow. *ZFW*, July, 1958, pp. 199–203. In German. Definition of several cases in which the Navier-Stokes equations of fluid motion can be integrated in closed form. The analysis is based on the study of a problem covering the motion of an incompressible viscous fluid in the upper semispace in the presence of a perpendicular axis covered with equally distributed sources of constant strength.

Two-Phase Flow. M. A. Santalo. *Appl. Mech. Rev.*, Oct., 1958, pp. 523–526. 26 refs. Survey of research on the co-current flow of a liquid and a gas or vapor of interest in film cooling of rocket engines.

O Podobii Transzvukovykh Ploskikh Potokov. G. N. Kopylov. *Prikl. Mat. i Mekh.*, May-June, 1958, pp. 391–395. In Russian. Development of a method for simplifying the basic equations of motion and derivation of similitude criteria for the case of transonic flows.

Aerodynamic Research on Fuselages with Rectangular Cross Section. K. Maruhn. (*Jahrbuch deutsch. Luftfahrtforsch.*, 1942, pp. 263–279.) *U.S., NACA TM 1414*, July, 1958. 37 pp. Translation. Presentation of the two-dimensional flow characteristics around square and rectangular cross sections with rounded edges as calculated by conformal mapping techniques, and comparison with corresponding results from elliptical and strictly rectangular cross sections. Some examples of the fuselage induced rolling moment due to sideslip are given.

Experiments on Two-Dimensional Base Flow at M = 2.4. L. Fuller and J. Reid. *Gt. Brit., ARC R&M 3064* (Feb., 1956) 1958. 34 pp. BIS, New York, $2.16. Investigation of a family of two-dimensional afterbodies to determine the effect of boat-tail angles and internal flow on the base pressure, the afterbody pressure, and the velocity distribution in the wake.

Compressible Inviscid Flow Near the End of Pointed Afterbodies. J. W. Reyn. *J. Aero/Space Sci.*, Dec., 1958, pp. 787, 788. Review of the properties of limit lines and discussion of the flow with axial symmetry around a cone extending upstream.

Hypersonic Flow Near the Forward Stagnation Point of a Blunt Body of Revolution. Hakuro Oguchi. *J. Aero/Space Sci.*, Dec., 1958, pp. 789, 790. Presentation of an approach to the problem when the thickness of the viscous layer is great enough to permit no distinc division of the flow field behind the shock wave.

Laminar Heat-Transfer and Pressure Measurements Over Blunt-Nosed Cones at Large Angle of Attack. Victor Zakkay. *J. Aero/Space Sci.*, Dec., 1958, pp. 794, 795. USAF-sponsored research.

A Modified Model of the Supersonic Laminar Wake. A. F. Charwat. *J. Aero/Space Sci.*, Dec., 1958, pp. 796, 797. Discussion covering the modified model and postulation of a mechanism explaining the transition from the constant laminar base-pressure "plateau" to the decreasing base pressure at low Reynolds Numbers.

Obtekanie Konusa pod Uglom Ataki s Bol'shoi Sverkhzvukovoi Skorost'iu. A. L. Gonor. *AN SSSR Otd Tekh. Nauk Izv.*, July, 1958, pp.102–105. In Russian. Development of a method of solution for the problem of flow around a cone in the case of high supersonic speed and angle of attack.

Turbulent Boundary-Layer and Skin Friction Measurements on an Artificially Roughened, Thermally Insulated Flat Plate at Supersonic Speeds. W. H. Shutts and F. W. Fenter. *Texas U. DRL Rep. 366*, Aug. 12, 1955. 97 pp. 16 refs.

Turbulent Boundary-Layer and Skin-Friction Measurements on a Smooth, Thermally Insulated Flat Plate at Supersonic Speeds. W. H. Shutts, W. H. Hartwig, and J. E. Weiler. *Texas U. DRL Rep. 364*, Jan. 5, 1955. 115 pp. 18 refs.

On the Structural Part of the Compressibility of Liquids. V. S. Venkatasubramanian. *Indian Inst. Sci. J., Sect. A*, July, 1958, pp. 132–139. Study of the "structural" part of the bulk modulus represented by the contribution of the entropy term in the free energy, and its relation to the temperature coefficient of the bulk modulus.

Cavitation Tests on Hydrofoil of Simple Form. III—On Four Profiles of Thickness Ratio 3.5 Per Cent. IV—Difference in Performance Between Experiments with Water Temperatures of 8 and 20 deg. C. V—On Four Profiles of 11.7 Per Cent Thickness Ratio. VI—On Three Profiles of 3.5 Per Cent Thickness Ratio. F. Numachi, K. Tsunoda, and I. Chida. *Tôhoku U. Rep. Inst. High Speed Mech.*, vol. 9, 1958, pp. 35–103. 10 refs.

O Laminarnom Techenii v Trubakh Zhidkostei s Razlichnoi Viakzost'iu. G. I. Maikapar. *AN SSSR Otd. Tekh. Nauk Izv.*, July, 1958, pp. 108–114. In Russian. Derivation of solutions for the laminar flow of liquids having different physical properties.

Introducing Magnetohydrodynamics. Arthur Kantrowitz. *Astronautics*, Oct., 1958, pp. 18–20, 74–77. Discussion of research being done in magnetohydrodynamics for possible applications to a space propulsion system, re-entry drag devices, and electric power generators.

Plane Problems in Magnetohydrodynamics. G. S. Golitsyn. (*Zhurnal Teoret. i Exper. Fis.*, Mar., 1958, pp. 688–693.) *Sov. Phys.-JETP*, Sept., 1958, pp. 473–477. Translation. Analysis of conditions for potential motion in magnetohydrodynamics. The Prandtl-Meyer problem for a conducting gas in a magnetic field and its generalizations and applications are studied in detail.

Ob Odnom Klasse Dvizhenii v Magnitnoi Gidromekhanike. V. N. Zhigulev. *Prikl. Mat. i Mekh.*, May-June, 1958, pp. 389, 390. In Russian. Analysis of a class of motions in magnetohydrodynamics.

Teorema Tsemplena v Magnitnoi Gidrodinamike. S. V. Iordanskii. *AN SSSR Dokl.*, Aug. 1, 1958, pp. 610–612. In Russian. Evaluation of Zemplen's theorem in magnetohydrodynamics.

Odnomernye Avtomodel'nye Dvizheniia Provodiashchego Gaza v Magnitnom Pole. V. P. Korobeinikov. *AN SSSR Dokl.*, Aug., 1, 1958, pp. 613–615. In Russian. Study of plane nonstationary adiabatic motion of a perfectly conducting gas with plane and cylindrical waves in the presence of a magnetic field.

A Note on One-Dimensional Plasma Motion. R. A. Gross. *J. Aero/Space Sci.*, Dec., 1958, pp. 788, 789. AFOSR-supported examination of some simple cases of plasma motion.

Plasma Heating of Supersonic Airstream. R. L. Chuan. *Phys. Fluids*, Sept.-Oct., 1958, p. 452.

Electromagnetic Radiation from Electrons Rotating in an Ionized Medium Under the Action of a Uniform Magnetic Field. Appendix—**Resolution of the Radiated Field Into Ordinary and Extraordinary Modes in the Limit of Vanishing Electron Density.** R. Q. Twiss and J. A. Roberts. *Australian J. Phys.*, Sept., 1958, pp. 424–446. 11 refs.

Interferometric Measurement of Electron Concentrations in Plasmas. R. A. Alpher and D. R. White. *Phys. Fluids*, Sept.-Oct., 1958, pp. 452, 453. USAF-supported research.

ITT

What's New in ITV

Many exciting new uses for closed circuit television save time, life, health and money for industry, military, education and business.

- In the Antarctic, the Navy uses CCTV on a helicopter to picture ice conditions to an ice breaker following.
- A utility using ITV to observe water levels saved three salaries.
- In handling freight, ITV inspected cars and gondolas from a distance.
- Watching oil drilling or diving operations on the ocean floor from the surface.
- Checking factory operations for floors above from the main floor saved time and money.
- Guiding bulldozers run automatically in radioactivity areas from a safe distance.
- Stores and markets cut shoplifting and pilferage with ITV.
- Flame patterns in combustion chambers of engines and boilers may now be observed.
- Large organizations reach dealers through ITV in many cities for simultaneous meetings.
- Traffic flow through tunnels or toll bridges is checked and controlled.
- TV camera on factory roof scans large roofs for fires.

ITT makes a complete and versatile line of closed circuit TV for every military, industrial, business and educational requirement. For bulletins, engineering data and other information call our nearest office.

Los Angeles, Calif. .... EMpire 7-6161
Detroit, Mich. ..... JEfferson 6-4040
Fort Myers, Fla. ... WYandotte 5-2151
Washington, D.C. ..... EMpire 5-1515
Denver, Colo. ..... AMherst 6-2714
New York City ..... OXford 5-0082
San Carlos, Calif. ..... LYtell 3-2189
Ft. Worth, Tex. . .. JEfferson 5-2056

Industrial Products Division

International Telephone and Telegraph Corp.
15191 Bledsoe St., San Fernando, California

Closed Circuit TV • Custom Power Equipment
Infra Red Equipment • Large Screen Oscilloscopes
Electronic Instruments • Autopilots for Aircraft

Stationary Convective Flow of an Electrically Conducting Liquid Between Parallel Plates in a Magnetic Field. G. Z. Gershuni and E. M. Zhukhovitskii. (*Zhurnal Teoret. i Exper. Fiz.*, Mar., 1958, pp. 670–674.) *Sov. Phys.- JETP*, Sept., 1958, pp. 461–464. Translation. Includes calculations for the distribution of velocity, temperature, induced fields, and convective heat flow for stationary convection between two vertical plates.

Issledovanie Protsessa Dissotsiatsii Kisloroda za Sil'noi Udarnoi Volnoi. S. A. Losev. *AN SSSR Dokl.*, June 21, 1958, pp. 1,291–1,293. In Russian. Experimental investigation of the speed of thermal dissociation behind a strong shock wave in oxygen.

I—The Stellarator Concept, Lyman Spitzer, Jr. **II—Equilibrium of a Magnetically Confined Plasma in a Toroid,** M. D. Kruskal and R. M. Kulsrud. **III—On the Stability of Plasma in Static Equilibrium,** M. D. Kruskal and C. R. Oberman. **IV—Some Stable Hydromagnetic Equilibria,** J. L. Johnson, C. R. Oberman, R. M. Kulsrud, and E. A. Frieman. **V—On the Ionization and Ohmic Heating of a Helium Plasma,** J. M. Berger, I. B. Bernstein, E. A. Frieman, and R. M. Kulsrud. **VI—Heating of a Confined Plasma by Oscillating Electromagnetic Fields,** J. M. Berger, W. A. Newcomb, J. M. Dawson, A. A. Frieman, R. M. Kulsrud, and A. Lenard. **VII—Generation and Thermalization of Plasma Waves,** T. H. Stix. *Phys. Fluids*, July-Aug., 1958, pp. 253–317. 86 refs.

Tables and Graphs of Normal-Shock Parameters at Hypersonic Mach Numbers and Selected Altitudes. P. W. Huber. *U. S., NACA TN 4352*, Sept., 1958. 26 pp. 17 refs. Presentation of data for real air in thermal and chemical equilibrium at conditions ahead of the shock corresponding to six selected altitudes, and for temperatures behind the shock from 2,000°K. to 11,000°K.

Primer Okolozvukovogo Techeniia Gaza s Oblast'iu Sverkhzvukovykh Skorostei, Ogranichennoi Vniz po Techeniiu Iskrivlennym Skachkom Uplotneniia, Okanchivaiushchimsia Vnutri Techeniia. I. Biibosunov. *Prikl. Mat. i Mekh.*, May-June, 1958, pp. 311–319. In Russian. Study of the problem of a transonic gas flow having a supersonic region bounded downstream by a curved shock within the stream.

O Predel'nykh Resheniiakh Vblizi Osobo Tochki. M. L. Lidov. *AN SSSR Dokl.*, June 21, 1958, pp. 1,224–1,227. In Russian. Derivation of a solution for nonlinear equations in the vicinity of a singular point, and evaluation of limit solutions for the general case used to study the problem of strong detonations and shock wave propagation.

Higher Order Interactions in Homogeneous Turbulence Theory. R. H. Kraichnan. *Phys. Fluids*, July-Aug., 1958, pp. 358, 359. AFOSR-supported discussion of the direct-interaction hypothesis used in a previous analysis of homogeneous turbulence.

O Turbulentnoi Diffuzii v Potoke s Poperechnym Gradientom Skorosti. A. A. Novikov. *Prikl. Mat. i Mekh.*, May-June, 1958, pp. 412–414. In Russian. Study of the turbulent diffusion in flow with a transverse velocity gradient.

O Spektral'nom Predstavlenii Aksial'nosimmetrichnoi Turbulentnosti Chandrasekara. A. A. Kovalev. *AN SSSR Dokl.*, June 21, 1958, pp. 1,220–1,223. In Russian. Spectral representation of axisymmetric turbulence of the Chandrasekhar type.

Vortex-Induced Vibration Studies. M. S. Macovsky. *U.S., Navy Dept., David Taylor Model Basin, Rep. 1190*, July, 1958. 15 pp. Presentation of techniques for measuring lift and drag forces and for analyzing wake structure. Measurements are given of the maximum alternating lift force coefficient in the Reynolds range $10^4 < R < 10^5$.

Internal Flow

Torque-Speed Characteristics for High-Specific-Work Turbines. W. L. Stewart. *U.S., NACA TN 4379*, Sept., 1958. 21 pp.

Effects of Stage Characteristics and Matching on Axial-Flow-Compressor Performance. Aubrey Stone. (*ASME Annual Meeting, New York, Dec. 1–6, Paper 57–A–139.*) *ASME Trans.*, Aug., 1958, pp. 1,273–1,289; Discussion, pp. 1,290–1,293.

Pumpen und Verdichter—Turboverdichter. Bruno Eckert. *VDI Zeitschrift*, Aug. 1, 1958, pp. 1,071–1,073. 14 refs. In German. Discussion covering the operation of axial and radial compressors.

Effect of Some External Crosswise Stiffeners on the Heat Transfer and Pressure Distribution on a Flat Plate at Mach Numbers of 0.77, 1.39, and 1.98. H. S. Carter. *U.S., NACA TN 4333*, Sept., 1958. 21 pp. Experimental investigation showing that the addition of stiffeners to flat plates causes large pressure and heat-transfer variations on the surface of the models.

Experimental Mixing Profiles of a Mach 2.6 Free Jet. E. T. Pitkin and Irvin Glassman. *J. Aero/Space Sci.*, Dec. 1959, pp. 791–793.

O Gazovykh Techeniiakh v Soplakh Lavalia. O. S. Ryzhov. *Prikl. Mat. i Mekh.*, May-June, 1958, pp. 396–398. In Russian. Study of the flow of an ideal gas in a Laval nozzle having two planes of symmetry.

O Raschete Sopla Lavalia. A. Sh. Dorfman. *Prikl. Mat. i Mekh.*, May-June, 1958, pp. 399–404. In Russian. Derivation of an approximate solution for calculating the supersonic region of a Laval nozzle.

Pumpen und Verdichter—Kreiselpumpen. Fritz Krisam and Klaus Saalfeld. *VDI Zeitschrift*, Aug. 1, 1958, pp. 1,069–1,071. 47 refs. In German. Discussion of the operation of centrifugal pumps, including cavitation and other factors.

The Centripetal-Pump Effect in a Vacuum Pump. M. Reiner. *Royal Soc. (London) Proc., Ser. A*, Sept. 16, 1958, pp. 152–167. 13 refs. Description of the centripetal vacuum pump and of two series of experiments. An exposition of theories of cross-stresses is made, and experimental results are interpreted on the basis of Maxwell's theory of the elastoviscosity of air.

Graphs of Reduced Variables for Computing Histories of Vaporizing Fuel Drops, and Drop Histories Under Pressure. G. L. Borman, M. M. El Wakil, O. A. Uyehara, and P. S. Myers. *U.S., NACA TN 4338*, Sept., 1958. 55 pp.

Stability & Control

Static Longitudinal and Lateral Stability Characteristics at Low Speed of 60° Sweptback-Midwing Models Having Wings with an Aspect Ratio of 2, 4, or 6. W. D. Wolhart and D. F. Thomas, Jr. *U.S., NACA TN 4397*, Sept., 1958. 41 pp.

Supersonic Wave Interference Affecting Stability. E. S. Love. *U.S., NACA TN 4358*, Sept., 1958. 19 pp. Calculations are presented to indicate the importance of interference fields created by wings, bodies, wing-body combinations, jets, and nacelles.

The Longitudinal Response of an Aircraft with Auto-Pilot, Including an Incidence Term in the Height Control Equation. Appendix I—**Aircraft Non-Dimensional Equations.** Appendix II—**Coefficients of Stability Equation.** M. R. Watts and D. E. Fry. *Gt. Brit., ARC CP 396* (Nov., 1957) 1958. 36 pp. BIS, New York, $0.90. Presentation of the results of a theoretical investigation into the dynamic stability of an aircraft under automatic height control.

Wings & Airfoils

Coefficients Aérodynamiques Instationnaires Théoriques en Régime Compressible Subsonique pour une Voilure de Faible Allongement. P. Salaün. *La Recherche Aéronautique*, July-Aug., 1958, pp. 29–34. In French. Extension of Lawrence and Gerber theories for the calculation of aerodynamic coefficients of low aspect ratio wings to the subsonic compressible case.

A Geometric Problem Related to the Optimum Distribution of Lift on a Planar Wing in Supersonic Flow. E. W. Graham. (*Douglas Rep. SM-23020*, Nov., 1957.) *J. Aero/Space Sci.*, Dec., 1958, pp. 771–774. 778. 19 refs.

A Summary and Analysis of the Low-Speed Longitudinal Characteristics of Swept Wings at High Reynolds Number. G. Ch. Furlong and J. G. McHugh. *U.S., NACA Rep. 1339*, 1957. 149 pp. 136 refs. Supt. of Doc., Wash., $1.50.

The Static Longitudinal Characteristics of a Twisted and Cambered 45° Sweptback Wing at Mach Numbers up to 0.96. R. I. Sammonds and R. M. Reynolds. *U.S., NACA RM A58C21*, Aug. 11, 1958. 26 pp. Test results indicating that the anticipated gains in maximum lift-drag ratio at high subsonic Mach Numbers due to the use of a distributed type of camber rather than one concentrated near the wing leading edge (conical camber) were not realized. The maximum lift-drag ratios for the two wing-body combinations, with roughness, were nearly the same throughout the range of these tests.

The Effects of Blunt Leading Edge on Delta Wings at Mach 5.8. K. F. Nicholson. (*GALCIT Memo. 45*, June 10, 1958.) *J. Aero/Space Sci.*, Dec., 1958, pp. 786, 787.

Investigation of Minimum Drag and Maximum Lift-Drag Ratios of Several Wing-Body Combinations Including a Cambered Triangular Wing at Low Reynolds Numbers and at Supersonic Speeds. C. E. Brown and L. K. Hargrave. *U.S., NACA TN 4020*, Sept., 1958. 62 pp. 19 refs.

Aeroelasticity

A Method of Damping Out Bending Vibrations of Beam-Like Structures by Solid Friction. Appendix I—**Relative Displacement of Cantilever and Damping Flange at Point of Contact.** Appendix II—**An Alternative Method of Introducing Friction Damping.** D. Williams. *Gt. Brit., RAE TN Struc. 241*, June, 1958. 41 pp. Discussion of a theory particularly applicable where the degree of damping required is represented by a ratio (damping/critical damping) not greater than 15 to 20 per cent.

On the Excitation of Pure Natural Modes in Aircraft Resonance Testing. R. W. Traill-Nash. (*Australia, ARL Rep. SM.254*, July, 1957.) *J. Aero/Space Sci.*, Dec., 1958, pp. 775–778.

Własności Funkcji Własnych dla Drgań Poprzecznych Belek Jednorodnych z Uwzględnieniem Wpływu Ścinania i Bezwładności Obrotowej. Danilo Raskovič. *Rozprawy Inżynierskie*, No. 2, 1958, pp. 203–218. In Polish, with summaries in English and Russian. Analysis of the properties of eigenfunctions for transverse vibrations of homogeneous beams, taking into account the influence of shearing and rotational inertia. The equation of motion is applied to 25 cases of end support at most general boundary conditions.

Comparaison des Résultats Obtenus en Soufflerie, sur une Aile d'Avion, par Application des Méthodes d'Excitation en vol Harmonique et Impulsionnelle. J. Nicolas. *La Recherche Aéronautique*, July-Aug., 1958, pp. 35–43. In French. Comparison of results obtained from wind-tunnel experiments on an aircraft wing by methods of harmonic and impulsive excitation.

Kolebaniia Svobodnoi Plastinki i Plastinki na Uprugom Osnovanii pod Deistviem Dinamicheskoi Nagruzki. F. A. Sokolov. *AN SSSR Otd. Tekh. Nauk Izv.*, Jule, 1958, pp. 114–117. In Russian. Study of the vibration of a free and an elastically supported plate under dynamic loading.

Ob Odnom Sposobe Rascheta Amplitud Avtokolebanii. V. I. Sergeev. *AN SSSR Otd. Tekh. Nauk Izv.*, July, 1958, pp. 90–93. In Russian. Derivation of a method for the calculation of amplitudes in the case of natural vibrations.

La Présentation et l'Interprétation des Calculs de Flottement de Gouverne en l'Absence de Servo-Commande. C. Béatrix. *La Recherche Aéronautique*, July-Aug., 1958, pp. 45–49. In French. Description of methods used for flutter calculations in the case of control surfaces without servocontrols.

How F-106 Was Flutter-Tested in Flight. J. W. Redd. *Space/Aeronautics*, Nov., 1958, pp 72–77. Description of flutter test equipment and procedures.

Détermination, par des Essais au Sol, des Constantes d'Inertie d'un Avion Suspendu. R. Kappus and D. Clerc. *La Recherche Aéronautique*, July-Aug., 1958, pp. 51–57. In French. Description of ground vibration tests for measuring the inertia constants of an aircraft model, including a description of the installation and experimental methods.

Free Undamped Non-Linear Vibrations of Imperfect Circular Disks. S. A. Tobias. (*IME Gen. Meeting, London, May 17, 1957.*) *IME Proc.*, No. 22, 1957, pp. 691–701; Discussion, pp. 702–705; Communications, pp. 706–710; Authors' Replies, pp. 711–715. 21 refs.

Elastically Supported Damper System Provides a New Method for Vibration Isolation. J. E. Ruzicka and R. D. Cavanaugh. *Mach. Des.*, Oct. 16, 1958, pp. 114–121.

Rezonansnye Kolebaniia Vrashchaiushchegosia Vala s Diskom. V. O. Kononenko. *AN SSSR Otd. Tekh. Nauk Izv.*, July, 1958, pp. 87–90. In Russian. Calculation of resonance vibrations such as are encountered in turbine rotors.

The Influence of Dynamical Imperfections on the Vibration of Rotating Disks. S. A. Tobias and R. N. Arnold. (*IME Gen. Meeting, London, May 17, 1957.*) *IME Proc.*, No. 22, 1958, pp. 669–690. 10 refs.

Aeronautics, General

Aeronautics International in Madrid. I, II. J. R. Cowie. *The Aeroplane*, Sept. 19; 26, 1958, pp. 473–475; 496, 497. Summary of papers on astronautical propulsion, re-entry cooling, VTOL & STOL, boundary-layer control, materials, and autopilots.

Gegenwartsprobleme der Luftfahrtforschung. H. L. Dryden. (*2nd Ludwig Prandtl Memorial Lecture, Munich, May 7, 1958.*) *ZFW*, Aug., 1958, pp. 217–233. 53 refs. In German. Discussion covering Prandtl's contribution to aeronautical research and a survey of such problems as aerodynamics, stability, and noise.

The Man-Powered Aircraft: A Design Study. T. R. F. Nonweiler. *RAeS J.*, Oct., 1958, pp. 723–734. 14 refs. Review of recent experimental and project work on the design of a very lightweight aircraft capable of being taken off and flown by two men. Emphasis is on the aerodynamic problems involved.

Rocket Research in Canada. R. F. Wilkinson. *CAI-IAS Joint Meeting, Ottawa, Oct. 7, 8, 1958, Preprint 847.* 11 pp. Members, $0.35; nonmembers, $0.75. Presentation of a general outline of the Canadian rocket propulsion program. The problem of improving the performance of rocket engines is discussed. Advance propulsion systems are considered.

Air Transportation

Commercial Air Cargo Potential. W. H. Arata, Jr. *Aero/Space Engrg.*, Dec., 1958, pp.

50–54. 12 refs. Discussion on the minimum range penetration of the cargo market by short-field aircraft. The trends in markets, common carriers, and design that will affect short-range cargo transportation are analyzed.

Britannia 253 Loading Equipment: Freighting Accessories Speed Aircraft Conversion in Military Role. *Shorts Quart. Rev.*, Sept., 1958, pp. 9–12.

Airplanes

Air Conditioning, Pressurization

Design Considerations for Air Conditioning Modern Aircraft. I. E. W. Still. *Can. Aircraft Ind.*, Aug., 1958, pp. 26–31. Discussion of temperature, airflow, humidity, cabin pressure, and oxygen control; equipment testing is also discussed.

Ekspluatatsiia Kislorodnogo Oborudovaniia Bombardirovshchika. L. P. Sosnov and Iu. G. Vladimirov. *Vestnik Vozdushnogo Flota*, July, 1958, pp. 62–67. In Russian. Description of the use of oxygen equipment in bomber aircraft.

Control Systems, Automatic Pilots

Special Issue: Fachheft Flugregelung. (*AFZ Lecture, Stuttgart, Sept. 22, 27, 1957.*) *Luftfahrttechnik*, Mar. 15, 1958, pp. 46–96. In German. *Partial Contents:* Geschichtliches zur Entwicklung der Flugregelungen, J. F. Wiren. Dreiachsen-Flugregelung für Hochleistungs-flugzeuge mit Integrations-Wendekreiseln als Hauptrichtgeber, H. J. Dudenhausen. Einige Betrachtungen über Flugregelungen für Hochleistungsflugzeuge, R. Hadekel and R. A. Summerlin. Zweifach-Flugregelungs-Anlage mit Zweifach-Überwachungsgeräten, H. Pöschl. Grundsätze der neuzeitlichen Flugregelung von Verkehrs-flugzeugen, insbesondere bezüglich automatischen Anfluges, Joseph Brodzik. Erfahrungen der Deutschen Lufthansa mit neuzeitlichen Auto-pilot-Anlagen, H. Gesler. Historical survey of the design, development, operation, and application of automatic control systems in terms of modern aircraft requirements. Includes evaluation of several types of autopilots, theoretical results, and experimental data.

Electro-Hydraulic Servo Designed for Variation in Flight. *Auto. Control*, Aug., 1958, pp. 14–16, 18, 19. Discussion of a system to alter in-flight stability characteristics in order to study stability parameters in more advanced aircraft.

Designing Safety Into Automatic Pilot Systems. C. W. McWilliams. *Electronics*, Nov. 7, 1958, pp. 69–71. Discussion of torque limiting and modulating circuits for control surfaces. These circuits prevent an overload on the surface.

The Role of Electrical Actuating Systems in Supplementing Seamaster Flight Controls. H. C. Zachmann. *CAI-IAS Joint Meeting, Ottawa, Oct. 7, 8, 1958, Preprint 846.* 11 pp. Members, $0.35; nonmembers, $0.75. Discussion of the various independent systems and their functions in regard to flight controls. Lateral and longitudinal control systems, as well as the operation of hydroflaps, are described.

Three Axes Flight Control System for High Performance Aircraft with Integrating Rate Gyroscopes as the Main Measuring Elements. H. J. Dudenhausen. (*Luftfahrttechnik*, No. 4, 1958, pp. 49–59.) *Gt. Brit., RAE Lib. Transl. 741*, June, 1958. 25 pp.

Description

"Last of the Fighters." *Aircraft & Missiles Mfg.*, Oct., 1958, pp. 10–14. Design and structural characteristics of the English Electric P.1B Lightning fighter.

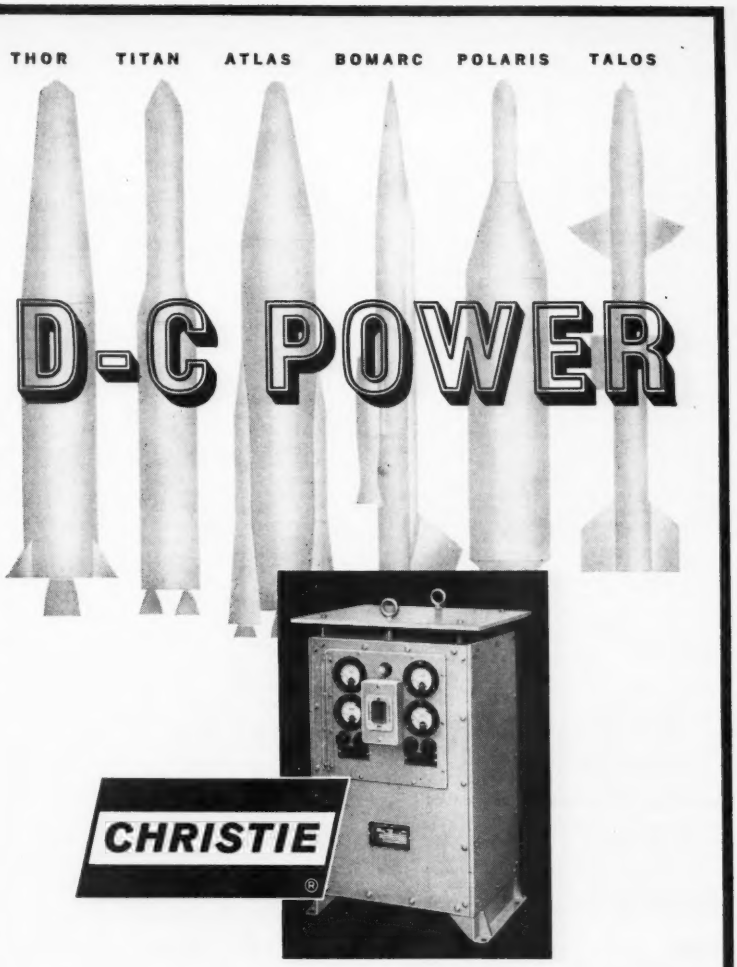
Reds' Yak-42 Bomber Beats B-47, Lags Behind B-58. *Space/Aeronautics*, Oct., 1958, pp. 40–46. Analysis of design and performance characteristics of the most recent Soviet medium range bomber.

Design

Argosy; A.W.A's New Transport. *Flight*, Oct. 17, 1958. pp. 619–629, cutaway drawing. Design, performance, structural, and systems characteristics of a British freighter-transport aircraft.

Wind-Tunnel Investigation of the Aerodynamic and Structural Deflection Characteristics of the Goodyear Inflatoplane. B. W. Cocke, Jr. *U.S., NACA RM L58E09*, Sept. 10, 1958. 56 pp. Presentation of tests for a range of speeds from minimum stall speed up to speeds giving load factors for wing buckling. Static aerodynamic and control data with wing-deflection photographs and wing-guy-cable loads are presented.

Wechselwirkung zwischen Formgebung und Konstruktion bei zukünftigen Flugzeugen. H. Hertel. *Luftfahrttechnik*, Sept. 15, 1958, pp. 243–251. In German. Evaluation of the interaction between shape and construction of future aircraft, including examples of current skin, stringer, and stiffener combinations with welded

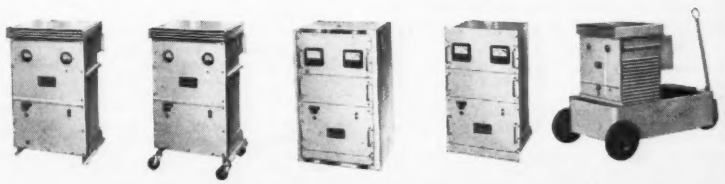


THERE IS A REASON...why *CHRISTIE* was selected as the principal source of D-C Power Supplies for all the above projects... **RELIABILITY**

CHRISTIE'S rigid Quality Control is approved by the A.E.C. and leading Aircraft and Missile Manufacturers.

CHRISTIE ELECTRIC CORP.
3410 W. 67th St., Los Angeles 43, Calif., Dept. AE

Precisely regulated Power Supplies of permanent stability. Ratings up to 1500 amperes. Bulletin on Standard Militarized units available on request.



and riveted fastenings, as well as possible configurations using sandwich structures.

Ejection Seats

Wind-Tunnel Investigation at Mach Numbers from 0.6 to 1.4 of Several Ejected Pilot-Seat Models. J. L. Summers. *U.S., NACA RM A58E02*, Sept. 10, 1958. 47 pp. Test results indicating that longitudinal and directional stability with possibly marginal dihedral effect can be achieved with the aid of stabilizing devices at the trim angles of attack over the Mach Number range investigated.

Fuel Tanks

Lightning Hazards to Aircraft Fuel Tanks. J. D. Robb, E. L. Hill, M. M. Newman, and J. R. Stahmann. *U.S., NACA TN 4326*, Sept., 1958. 58 pp. Evaluation of the dangers of lightning striking a fuel tank by studying the basic mechanisms of fuel-tank ignition in various environmental and flight conditions.

Landing, Landing Loads

Blind Landing of Aircraft. *The Engr.*, Oct. 24, 1958, pp. 648–650. Description of a completely automatic landing system. Research made on other blind landing methods and on visual aids is briefly discussed.

Measurements of Ground-Reaction Forces and Vertical Center-of-Gravity Accelerations of a Bomber Airplane Taxiing Over Obstacles. J. M. McKay, R. H. Sawyer, and A. W. Hall. *U.S., NACA TN 440*, Sept., 1958. 30 pp. Test results for the effects of speed and the widths and heights of obstacles on the vertical and rearward drag ground-reaction forces, the vertical acceleration of the center of gravity of the aircraft, the shock-strut displacement, and the dynamic response of the upper mass of the aircraft structure.

Landing Gear

Recent Advances in Design of Aircraft Tires and Brakes. II—Brakes. H. W. Trevaskis. (*RAeS J.*, Mar., 1958, pp. 203–211.) *Ind. Aeronautics*, June, 1958, pp. 21–24.

Operating Characteristics, Economics

Operazioni di Volo con Velivoli a Getto di Grande Tonnellaggio. Carlo Jereb. *Riv. Aero.*, Sept., 1958, pp. 1,309–1,333. In Italian. Discussion of various problems of jet aircraft operation including such aspects as economics, airports, traffic control, navigation systems, communications, and meteorological data.

Piloting

Piloting Research Aircraft. Joseph Walker. *CAI-IAS Joint Meeting, Ottawa, Oct. 7, 8, 1958, Preprint 860.* 13 pp. Members, $0.35; nonmembers $0.75. Discussion of control problems experienced in flying advanced research and production aircraft for the NACA. Solutions of these problems were obtained by improved design, better airborne and ground aids, and improved methods of flight testing.

Broad Outline of Aircraft Feel Pilot's Appreciation. W. J. Fotocki. *CAI-IAS Joint Meeting, Ottawa, Oct. 7, 8, 1958, Preprint 854.* 23 pp. Members, $0.65; nonmembers, $1.00. Discussion from the pilot's point of view of the principles underlying the understanding of aircraft feel. The problem is concentrated on the elevator and aileron systems.

Airports

A Preliminary Evaluation of Narrow-Gauge Runway Lighting and Runway Surface Illumination. J. H. Harding, R. C. Herner, and R. F. Gates. *U.S., CAA TDR 338* (*OTS PB 131729*, $0.50.), Feb., 1958. 11 pp.

Heliports

Heliport Requirements in Congested Areas. D. E. Postle. *AHS J.*, July, 1958, pp. 10–16.

Aviation & Space Medicine

Aviation Medicine on the Threshold of Space: A Symposium—Achievements of the Past Year. P. A. Campbell. (*Aero Med. Assoc. 29th Annual Meeting, Wash., Mar. 24, 1958.*) *J. Av. Med.*, July, 1958, pp. 458–492.

Accommodating the Space Man. C. P. Phoebus. *Res. Rev.*, June, 1958, pp. 6–12. Discussion of the major problems of manned space flight, including radiation, acceleration and deceleration, environmental temperatures, and other factors.

Man in Space: Metabolic Data, Stresses Encountered, and Ground Test Facilities. C. M. Whitlock, Jr. *IAS Natl. Summer Meeting, Los Angeles, July 8–11, 1958, Paper.* 14 pp. Discussion of some of the problems posed in providing man with an operational environment in space vehicles, and presentation of some data on these problems.

Special Issue: The Human Factor in Space Travel. *Air U. Quart. Rev.*, Summer, 1958, pp. 2–146. 111 refs. *Partial Contents:* The Threshold of Space, C. D. Ogle. From Aviation Medicine to Space Medicine, Hubertus Strughold. Air Force Human-Factors Program for Developing Manned Space Operations, D. Flickinger. Basic Factors in Manned Space Operations, Hubertus Strughold. Biodynamics of Manned Space Flight, J. P. Stapp. The Engineered Environment of the Space Vehicle, H. G. Clamann. Observations in High-Altitude, Sealed-Cabin Balloon Flight, D. G. Simons. Human Performance in the Space Travel Environment, G. T. Hauty. Human Requirements for Space Travel, S. B. Sells and Ch. A. Berry. Weightlessness, S. J. Gerathewohl.

The Role of Physical Standards in Jet and Rocket Aircraft Flight. Ch. A. Berry. (*Aero Med. Assoc. 29th Annual Meeting, Wash., Mar. 24, 1958.*) *J. Av. Med.*, Sept., 1958, pp. 631–640. 26 refs.

A Closed Food Cycle Atomic Conservation for Space Flight. C. C. Clark. (*Aero Med. Assoc. 29th Annual Meeting, Wash., Mar. 24, 1958.*) *J. Av. Med.*, July, 1958, pp. 535–539.

Health Hazards of New Aircraft and Rocket Propellants: A Review of the Literature. A. R. Stumpe. (*Aero Med. Assoc. 29th Annual Meeting, Wash., Mar. 24, 1958.*) *J. Av. Med.*, Sept., 1958, pp. 650–659. 40 refs.

Protection Against Acceleration Forces in Animals by Immersion in Water. R. Margaria, T. Gualtierotti, and D. Spinelli. (*Aero Med. Assoc. 28th Annual Meeting, Denver, May 7, 1957.*) *J. Av. Med*, June, 1958, pp. 433–437.

G Tolerance in Primates. I—Unconsciousness End Point. G. H. Kydd and A. M. Stoll. *J. Av. Med.*, June, 1958, pp. 413–421. Investigation to establish for a monkey an end point during response to acceleration which is indicative of unconsciousness. The experimental procedure is described and results are discussed.

Explosive Recompression. Hansjörg Kolder. (*2nd Europ. Av. Med. Congr., Stockholm, Sept. 17, 1957.*) *J. Av. Med.*, Sept., 1958, pp. 690–695. 14 refs. Study of the mechanical effects of sudden pressure increase, with precautions taken to exclude possible consequences of a preceding exposure to low pressures, such as lack of oxygen or the formation of gas bubbles.

Potentialities and Ramifications of Life Under Extreme Environmental Conditions. D. E. Beischer. (*Aero Med. Assoc. 29th Annual Meeting, Wash., Mar. 24, 1958.*) *J. Av. Med.*, July, 1958, pp. 500–503.

Requirements for Experimental Zero Gravity Parabolas. J. E. Ward. *J. Av. Med.*, June, 1958, pp. 428–432.

Functional Mock-Ups for Aircrew. M. G. Whillans. *CAI-IAS Joint Meeting, Ottawa, Oct. 7, 8, 1958, Preprint 852.* 7 pp. 10 refs. Members, $0.35; nonmembers, $0.75. Application of working mock-ups to solve problems in human engineering of aircraft cockpits and cabins.

Bibliography of Unclassified Human Engineering Reports. *U.S., NTDC NAVEXOS P-1491*, Jan. 1, 1958. 18 pp. 433 refs.

Experiments during Weightlessness; A Study of the Oculo-Agravic Illusion. S. J. Gerathewohl and H. D. Stallings. (*Aero Med. Assoc. 29th Annual Meeting, Wash., Mar. 24, 1958.*) *J. Av. Med.*, July, 1958, pp. 504–516. 18 refs.

Visual Defects in Military Flyers; A Survey of 825 Officers. I. L. Hoffman and J. W. Koehler. *J. Av. Med.*, July, 1958, pp. 549–554.

Study of Visual Acuity During the Ocular Pursuit of Moving Test Objects. I, II—Effects of Direction of Movement, Relative Movement, and Illumination. J. W. Miller and Elek Ludvigh. *OSA J.*, Nov., 1958, pp. 799–808. ONR-supported research.

Gross Pattern of Injury of 109 Survivors of Five Transport Accidents. A. H. Hasbrook. *Cornell U. Rep. Av-CIR-5-SS-96*, July, 1958. 54 pp.

Medical Investigation of Aircraft Accidents with Multiple Casualties. V. A. Stembridge, W. M. Crafft, and F. M. Townsend. *J. Av. Med.*, Sept., 1958, pp. 668–675. Survey of suggested methods for handling multiple casualties from aircraft accidents.

Design Considerations of a Balloon-Borne Pressurized Capsule of High Altitude Bailout Study. E. E. Beson. (*Aero Med. Assoc. 29th Annual Meeting, Wash. Mar. 24, 1958.*) *J. Av. Med.*, July, 1958, pp. 516–525.

The Effects of Venous Infusion of Gaseous Carbon Dioxide Into Dogs. F. G. Hall, John Salzano, and Fred Zechman, Jr. (*Aero Med. Assoc. 29th Annual Meeting, Wash., Mar. 25, 1958.*) *J. Av. Med.*, July, 1958, pp. 544–548.

Oxygen Toxicity in Aviation Medicine; An Analysis of Recent Literature. P. F. Mullinax, Jr., and D. E. Beischer. (*Aero Med. Assoc. 29th Annual Meeting, Wash., Mar. 25, 1958.*) *J. Av. Med.*, Sept., 1958, pp. 660–667. 26 refs.

New Knowledge of the Extra-Atmospheric Radiation Field. H. J. Schaefer. (*Aero Med. Assoc. 29th Annual Meeting, Wash., Mar. 24, 1958.*) *J. Av. Med.*, July, 1958, pp. 492–500. Quantitative appraisal of the radiation effects on man in the extra-atmospheric region, with a discussion of new experimental data.

Chemistry

Contributions to Trace Analysis. I—Trace Analysis of High Purity Aluminium and Aluminium Compounds. O. G. Koch. (*Mickrochim. Acta*, No. 1, 1958, pp. 92–103.) *Gt. Brit., RAE Lib. Transl. 749*, July, 1958. 11 pp. 26 refs.

Heat Content of Zirconium and of Five Compositions of Zirconium Hydride from 0° to 900°C. T. B. Douglas and A. C. Victor. *J. Res.*, July, 1958, pp. 13–23. 13 refs. USAF-supported investigation.

A New Rapid Method for the Decomposition of Micro, Semimicro and Macro Samples Using Alkali Peroxide in a Universal Bomb. B. Wurzschmitt. (*Mikrochem.*, No. 36/37, 1951, pp. 769–780.) *Gt. Brit., RAE Lib. Transl. 754*, July, 1958. 10 pp. 12 refs.

Self-Diffusion in Alpha Solid Solutions of Silver-Cadmium and Silver-Indium. Appendix —Correction for Isotope Mass in Counting of CD^{109}. Alan Schoen. *Convair Sci. Res. Lab. RR2*, Mar., 1958. 160 pp. 70 refs. Measurement of radioactive tracer diffusion coefficients for both solvent and solute atoms, carried out in homogeneous alpha solid solutions of Ag-Cd and Ag-In in the temperature range between 500°C. and 900°C.

Mass Spectrometric Study of the Rate of Thermal Decomposition of Hydrazoic Acid. J. L. Franklin, V. H. Dibeler, and P. P. Morris, Jr. *J. Res.*, July, 1958, pp. 41–46. Army-supported investigation.

De l'Influence de la Solvatation des Ions sur la Conductibilité des Electrolytes. Luc-Henry Collet. *France, Min. de l'Air NT 76*, 1958. 27 pp. 33 refs. SDIT, 2 Av. Porte-d'Issy, Paris 15, Frs. 650. In French. Investigation of the effect of ion solvation on the conductibility of electrolytes.

Computers

Special Issue: Symposium on Computers in Simulation, Data Reduction, and Control. *IRE Trans., EC Ser.*, June, 1958, pp. 123–164. 515 refs. *Partial Contents:* Digital Computers in Continuous Control Systems, E. L. Braun. Computers in Process Industry Control, W. F. Gunning. Aspects of Real-Time Simulation, W. F. Bauer. Digital Information Processing for Machine-Tool Control, A. K. Susskind. Realization of Randomly Timed Computer Input and Output by Means of an Interrupt Feature, L. R. Turner and J. H. Rawlings. Logical Machine Design: A Selected Bibliography, D. B. Netherwood.

General Purpose Programming Systems. A. W. Holt. *Assoc. Comp. Mach. Commun.*, May, 1958, pp. 7–9.

Automatic Implementation of Computer Logic. E. F. Morris and T. E. Wohr. *Assoc. Comp. Mach. Commun.*, May, 1958, pp. 14–20.

An Improved Decimal Redundancy Check. R. L. Sisson. *Assoc. Comp. Mach. Commun.*, May, 1958, pp. 10–12.

Der Einfluss der elektronischen Rechenanlagen auf die Arbeit des Ingenieurs. Franz Nechleba. *VDI Zeitschrift*, Sept. 11, 1958, pp. 1,263, 1,264. 16 refs. In German. Discussion covering the operation of electronic computers and their application to engineering problems.

On the Analysis of Sequential Machines. R. G. Gillespie and D. D. Aufenkamp. *IRE Trans., EC Ser.*, June, 1958, pp. 119–122. Application of methods of algebraic solution of Markov chains with constant transition probabilities to the analysis of sequential machines. A technique is formulated for reducing the connection matrix of any sequential machine to a canonical form.

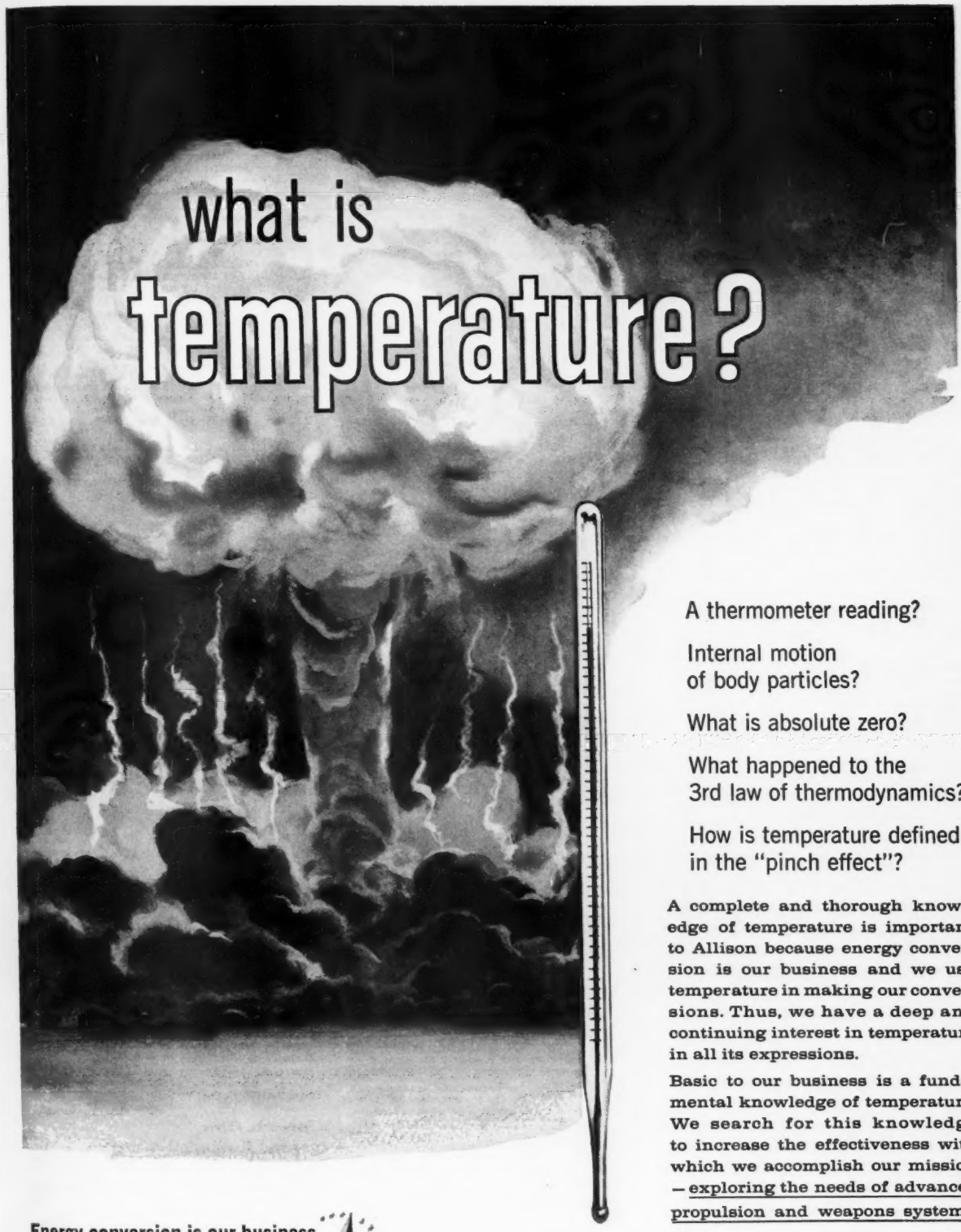
A Novel Type of Isograph (Algebraic Equation Solver). P. V. Rao. *IRE Trans., EC Ser.*, June, 1958, pp. 97–103. 15 refs. Description of the development, design, and construction of an inexpensive, portable isograph capable of locating the roots of a polynomial with fairly high accuracy.

A New Transistor-Magnetic Core Bi-Logical Computer Element. W. J. Dunnet and A. G. Lemack. *Auto Control*, Sept., 1958, pp. 32–39. 12 refs.

A Load-Sharing Matrix Switch. G. Constantine, Jr. *IBM J. Res & Devel.*, July, 1958, pp. 205–211. Development of a matrix-switch winding pattern which allows the power from several pulse generators to be combined into a single high-power pulse to drive a computer core memory.

Design of AC Computing Amplifiers Using Transistors. C. A. Krause and R. R. Lowe. *IRE Trans., EC Ser.*, Sept., 1958, pp. 191–195.

A Direct-Reading Printed-Circuit Commutator for Analog-to-Digital Data Conversion. C. A.



A thermometer reading?

Internal motion of body particles?

What is absolute zero?

What happened to the 3rd law of thermodynamics?

How is temperature defined in the "pinch effect"?

A complete and thorough knowledge of temperature is important to Allison because energy conversion is our business and we use temperature in making our conversions. Thus, we have a deep and continuing interest in temperature in all its expressions.

Basic to our business is a fundamental knowledge of temperature. We search for this knowledge to increase the effectiveness with which we accomplish our mission — exploring the needs of advanced propulsion and weapons systems.

Energy conversion is our business

ALLISON

Division of General Motors, Indianapolis, Indiana

Walton. *IBM J. Res. & Devel.*, July, 1958, pp. 179–192.

An Automatic Graph Plotter. J. J. Morrison. *Soc. Instr. Tech. Trans.*, June, 1958, pp. 55–66; Discussion, pp. 66, 67. Discussion of the adaptation of an analog plotting table using a digital-to-analog conversion technique with digital scaling and zero suppression, and automatic selection of the printed symbol.

An Electrical-Analog Method for Transient Heat-Flow Analysis. A. F. Robertson and Daniel Gross. *J. Res.*, Aug., 1958, pp. 105–115. 17 refs. Description of an electronic device for the solution of transient heat-flow problems by means of analogous resistance-capacitance electrical networks. The reliability and flexibility of the instrument are demonstrated. Some applications to the field of fire research are described.

Fast Data Processing Key to Atlas Testing. C. A. Walruff. *Space/Aeronautics*, Nov., 1958, pp. 56–63. Description of a data processing system for efficient missile testing.

Techniques of Smoothing Discrete Data and Their Applicability to Track-While-Scan Systems. J. E. Hanson and J. W. Follin, Jr. (*Quart. Rev. Bumblebee Activ.*, July-Dec., 1957.) *The Johns Hopkins U., APL BB Rep. 274*, 1958, pp. 32–37.

A New Class of Digital Division Methods. J. E. Robertson. *IRE Trans., EC Ser.*, Sept., 1958, pp. 218–222.

Digital Computer Adding and Complementing Circuits. C. D. Florida. *Electronic Eng.*, July, 1958, pp. 429–435.

A Basic Transistor Circuit for the Construction of Digital-Computing Systems. P. L. Cloot. (*IEE Paper 2585 M.*) *IEE Proc., Pt. B*, May, 1958, pp. 213–220.

Logically Micro-Programmed Computers. J. V. Blankenbaker. *IRE Trans., EC Ser.*, June, 1958, pp. 103–109. Description of simple digital computers exploiting the concepts of simulation and micro-programming. Design techniques for computers employing only multiple-bit time delays are also given.

Transac C-1100: Transistorized Computers for Airborne and Mobile Systems. G. L. Hollander. *IRE Trans., ANE Ser.*, Sept., 1958, pp. 159–169. 14 refs.

Inertial Guidance System Uses Digital Integrator. H. J. Weber. *Space/Aeronautics*, Nov., 1958, pp. 134–138. 140–143 (ff).

Short-Cut Multiplication and Division in Automatic Binary Digital Computers. M. Lehman. (*IEE Paper 2603 M.*) *IEE Proc., Pt. B*, Sept., 1958, pp. 496–504.

Algebraic Formulation of Flow Diagrams. E. A. Voorhees. *Assoc. Comp. Mach. Commun.*, June, 1958, pp. 4–8.

Applying Computers to Air Traffic Control. H. S. Stokes. *IRE Trans., ANE Ser.*, Sept., 1958, pp. 152–159. 18 refs.

Circuit Reliability. G. A. Raymond. *Ordnance*, Sept.-Oct., 1958, pp. 327–329. Discussion on the approach used and the results achieved in the development of the basic electronic circuitry and packaging of a computer for the intercontinental ballistic missile.

Curve Fitting for a Model of Applied Research and Development Scheduling. P. V. Norden. *IBM J. Res. & Devel.*, July, 1958, pp. 232–248. 24 refs.

Philosophy and Mechanization of an Air-Data Computer. J. H. Andresen, Jr., and H. F. Colvin, III. *ASME-ARS Joint Av. Conf., Dallas, Mar. 17–20, 1958, Paper 58-AV-15.* 5 pp.

Design Considerations of Information Storage and Retrieval Machines. Frederick Jonker. *Documentation Inc. Paper (AFOSR TN 58-367) [AD 154273]*, Apr., 1958. 25 pp.

On the Quantization of Finite Dimensional Messages. M. P. Schützenberger. *Info. & Control*, May, 1958, pp. 153–158. USAF-Army-Navy-sponsored study.

Finite State Languages. Noam Chomsky and G. A. Miller. *Info. & Control*, May, 1958, pp. 91–112. USAF-Army-Navy-supported discussion of a number of equivalent descriptions of finite state languages, and the establishment of a simple structural characterization theorem for finite state languages, based on the cyclical structure of grammar.

The Design of an Intelligent Automation. Frank Rosenblatt. *Res. Trends (Cornell Aero. Lab.)*, Summer, 1958, pp. 1–7. Description of the design and operation of the perceptron—a machine which senses, recognizes, remembers, and responds like the human mind. Possible applications are discussed.

Control Theory

The Design of Cascade Control Systems. R. L. Day. *Soc. Instr. Tech. Trans.*, June, 1958, pp. 76–84; Discussion, pp. 84–86.

Les Circuits Logiques—Principes et Applications. A. Sageau. *Docaéro*, July, 1958, pp. 57–60. In French. Description of basic electric circuits used in automatic control systems, including their application to aircraft systems.

Investigations of Magnetic Amplifiers with Feedback. H. J. Gray, Jr. *IRE Trans., EC Ser.*, Sept., 1958, pp. 213–217. Study of sine wave carrier excited magnetic amplifiers to determine if the figure of merit can be improved through the use of feedback techniques.

Grain Equalization of Linear Servomechanisms That Solve Nonlinear Equations. G. E. Adams. *Elec. Commun.*, No. 1, 1958, pp. 15–27.

Dynamic Stability of Servo-Governors for Air Driven Turbo-Alternators. D. O. Burns, T. S. Law, and C. F. Vance. *Gt. Brit., RAE Rep. El. 1488*, July, 1958. 119 pp. 10 refs. Study of a governing system using an electronic or a magnetic control amplifier followed by a section of hydraulic amplification to work the throttle valve of the turbine.

Education & Training

Some Observations on Engineering Education. F. E. Terman. (*IAS Natl. Summer Meeting, Los Angeles, July 8–11, 1958.*) *Aero/Space Engrg.*, Dec., 1958, pp. 48, 49, 54.

Adaptability Screening of Flying Personnel; Cross-Validation of the Personal History Blank Under Field Conditions. S. B. Sells, D. K. Trites, R. C. Templeton, and M. R. Seaquist. (*Aero Med. Assoc. 29th Annual Meeting, Wash., Mar. 26, 1958.*) *J. Av. Med.*, Sept., 1958, pp. 683–689. 11 refs.

The Design of Training Equipment. C. P. Seitz. *CAI-IAS Joint Meeting, Ottawa, Oct. 7, 8, 1958, Preprint 855.* 5 pp. Members, $0.35; nonmembers, $0.75. Discussion of fundamental problems in sensing, learning, and decision making as they are applied to the design of training simulators.

Electronics

Amplifiers

Theory of the Maser and Maser Fluctuations. V. S. Troitskii. (*Zhurnal Teoret. i Exper. Fiz.*, Feb., 1958, pp. 390–393.) *Sov. Phys.-JETP*, Aug., 1958, pp. 271–273. 12 refs. Translation. Analysis considering a maser as an oscillating system with one degree of freedom, the steady-state oscillations of which are described by the Basov-Prokhorov equations. It is shown that there is a "soft" mode and an analog of the "hard" mode, which is preceded by a region of noise generation.

Gain, Band Width, and Noise Characteristics of the Variable-Parameter Amplifier. Appendix I—**Two-Tank Circuit as a Frequency Converter.** Appendix II—**Derivation of the Terms in the Noise Figure Expression for the Amplifier.** Appendix III—**Modification of the Analysis for a General Nonlinear Variable Element.** H. Heffner and G. Wade. *J. Appl. Phys.*, Sept., 1958, pp. 1, 321–1,331. USAF-Army-Navy-supported research.

Broad-Band Amplifier for Radar and Scatter. J. H. Phillips and E. Maxwell. *Electronics*, Sept. 26, 1958, pp. 81–83.

Antennas, Radomes

How to Determine Gain for Large Aperture Antennas in the Fresnel Region. Ernest Jacobs. *Electronic Des.*, Nov. 12, 1958, pp. 30–33.

Measured Self-Impedance of a Dipole Antenna Near a Conducting Cylinder of Elliptical Cross Section. J. Y. Wong. *Can. J. Phys.*, July, 1958, pp. 855, 856. Measurements carried out for various spacings of the antenna from the cylinder along the major and minor axes, and for four different values of cylinder ellipticity.

Exploration de Résonances en Antennes de Bord. D. H. Marin and D. M. Bautista. *Tech. & Sci. Aéronautiques*, Dec., 1957, pp. 285–292. In French. Investigation of the resonance of aircraft antennas and presentation of methods for measuring this resonance by means of a Ferisol Q-meter. Theoretical and experimental values of resistance and reactance are plotted for flight and ground conditions.

Use of Scale Model Techniques in the Design of V. H. F. and U. H. F. Aerials. F. J. H. Charman, J. Thraves, and E. F. Walker. *Electronic Eng.*, Aug., 1958, pp. 498–501. Discussion of the theory and practical methods of measuring radiation patterns of complex aerial systems by scale models; several examples are presented.

Boeing 707 Fin Tip. U. W. Massie. *Aircraft & Missiles Mfg.*, Oct., 1958, pp. 16–20. Discussion on the production of a plastic laminate antenna for the Boeing 707.

Circuits & Components

DC-AC Inverter is Simple, Precise. Benjamin Barron. *Space/Aeronautics*, Nov., 1958, pp. 144–146, 148–152. Description of the inverter system using a tuning-fork oscillator and transistor booster amplifier.

A Transistor Pulse Generator for Digital Systems. D. J. Hamilton. *IRE Trans., EC Ser.*, Sept., 1958, pp. 244–249.

Analytical Design of Resistor-Coupled Transistor Logical Circuits. M. W. Marcovitz and E. Seif. *IRE Trans., EC Ser.*, June, 1958, pp. 109–119.

Characteristics of Silicon-Diode Switch Demodulators. R. E. Gorozdos and R. L. Konigsberg. (*Quart. Rev. Bumblebee Activ.*, July-Dec., 1957.) *The Johns Hopkins U., APL BB Rep. 274*, 1958, pp. 21–31. Description of circuit operation and examination of the performance characteristics of four specific demodulators.

Electrical Breakdown of Microwave Components. G. K. Hart, F. R. Stevenson, and M. S. Tanenbaum. *Electronic Des.*, Oct. 15, 1958, pp. 36–39. Analysis of the results of a theoretical and experimental study concerning the electrical breakdown of microwave components. Plots useful in predicting the breakdown are discussed.

Communications

Single Sideband Aircraft Communication. G. L. Grisdale. *Wireless World*, Oct., 1958, pp. 460–465. Description of the operation and advantages of the system. Technical problems involved in its introduction to civil air routes are discussed.

Time-Compressed Single-Band System (Ticoss). M. I. Jacob and J. Mattern. (*3rd Annual Aero. Commun. Symposium, Utica, Nov. 6, 1957.*) *IRE Trans., CS Ser.*, June, 1958, pp. 2–8.

Choosing the Optimum Type of Modulation—A Comparison of Several Communication Systems. G. J. Kelley. (*3rd Annual Aero. Commun. Symposium, Utica, Nov. 6, 1957.*) *IRE Trans., CS Ser.*, June, 1958, pp. 14–21. 21 refs.

Evaluation of IF and Baseband Diversity Combining Receivers. R. T. Adams and B. M. Mindes. *IRE Trans., CS Ser.*, June 1958, pp. 8–13. Theoretical and experimental study comparing the two methods used in tropospheric scatter systems.

Cooling

Liquid Cooling of Electronic Equipment. E. N. Shaw. *Electronic Eng.*, Sept., 1958, pp. 516–523. Study of liquid cooling potentialities to determine the effectiveness of heat exchangers built into electronic equipment as integral parts of the assembly.

Electronic Tubes

Low-Noise Tube May Boost Radar Range. P. J. Klass. *Av. Week*, Sept. 1, 1958, pp. 64, 65. Development of a low-noise, high-gain amplifying tube; its advantages and operation are described.

Magnetic Devices

Ferrites. Ernst Albers-Schoenberg. *Am. Ceram. Soc. J.*, Pt. II, Nov., 1958, pp. 484–489. 22 refs. Discussion of the system of classification and description of the four groups with respect to chemical constitution.

Microstructure and Properties of Ferrites. S. L. Blum. *Am. Ceram. Soc. J.*, Pt. II, Nov., 1958, pp. 489–493. Review of domain behavior and its relation to micro-structure of magnetic materials. The critical grain size necessary to maintain a single domain in nickel ferrite is calculated.

The Thermodynamical Theory of Resonance and Relaxation Phenomena in Ferromagnetics. G. V. Skrotskii and V. T. Shmatov. (*Zhurnal Teoret. i Exper. Fiz.*, Mar., 1958, pp. 740–745.) *Sov. Phys.-JETP*, Sept., 1958, pp. 508–511. 11 refs. Translation.

On the Theory of Ferromagnetic Superconductors. G. F. Zharkov. (*Zhurnal Teoret. i Exper. Fiz.*, Feb., 1958, pp. 412–416.) *Sov. Phys.-JETP*, Aug., 1958, pp. 286–289. Translation. Calculation of the conditions for the existence of a superconducting state in bulk, single-domain ferromagnetic samples with the shape of an ellipsoid of revolution.

A Guide to Ferromagnetic Ceramics. I, II. George Economos. *Materials in Des. Eng.*, Sept.; Oct., 1958, pp. 96–101; 109–114. 13 refs.

Networks, Filters

Formal Analysis and Synthesis of Bilateral Switching Networks. R. E. Miller. *IRE Trans., EC Ser.*, Sept., 1958, pp. 231–244. 14 refs.

Synthesis of Series-Parallel Network Switching Functions. Warren Semon. *Bell System Tech. J.*, July, 1958, pp. 887–898.

A Note on Contact Networks for Switching Functions of Four Variables. Roderick Gould. *IRE Trans., EC Ser.*, Sept., 1958, pp. 196–198.

Quick Design of Thermistor Compensation Networks. II. B. R. Schwartz. *Electronic Des.*, Oct. 15, 1958, pp. 104–107. Consideration of the temperature characteristics of networks using two resistors in addition to a thermistor.

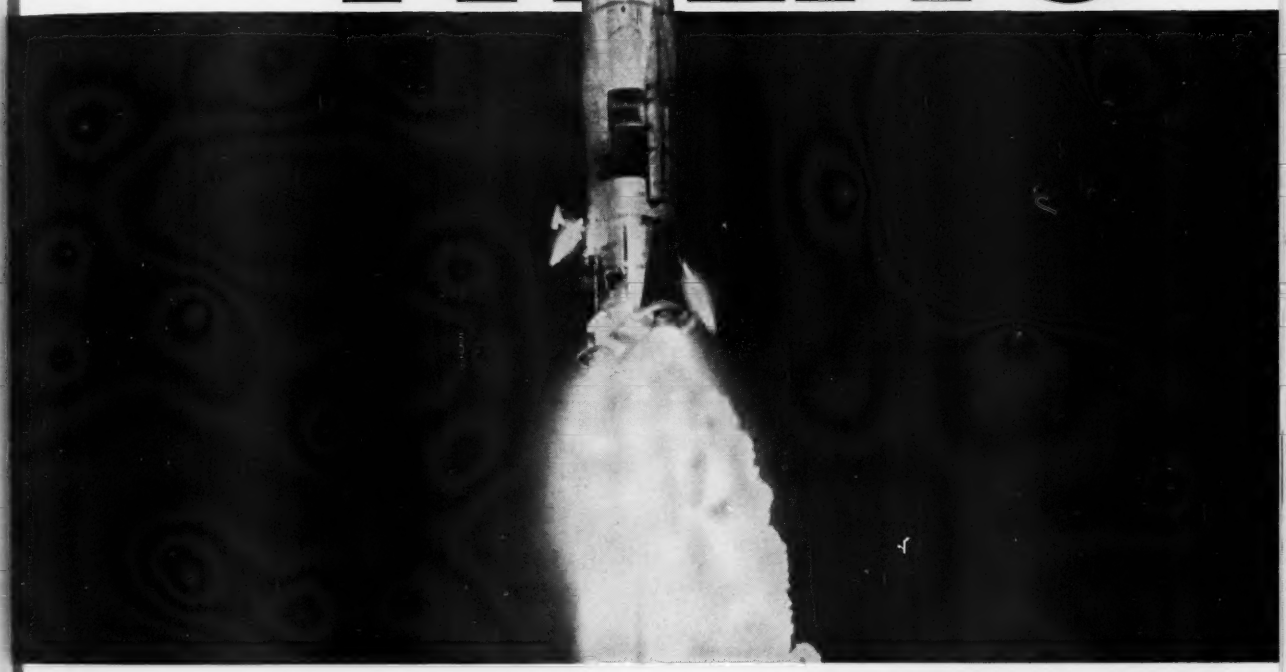
Noise, Interference

Research on Noise in High Powered Klystrons. W. R. Atkinson. *Philips Lab. TR 129 (AFOSR*

Preserver of Peace . . .

ATLAS

Air Force "Sunday Punch"



Boosted into space by the fiery thrust of three huge rocket engines, the seven-story Atlas intercontinental ballistic missile roars upward from its Cape Canaveral launching pad. Quickly it sheds the frost encrusting the liquid oxygen tank and races to its predetermined destination in the far reaches of the globe. In its size and range and capability, the Air Force Atlas is a commentary, for all the world to heed, of the necessity to maintain the peace. RCA's Missile and Surface Radar Department has been privileged to design and develop ground check-out, launch control and cabling equipment as a major subcontractor to Convair (Astronautics) Division of General Dynamics Corporation, the Atlas prime weapons systems contractor.

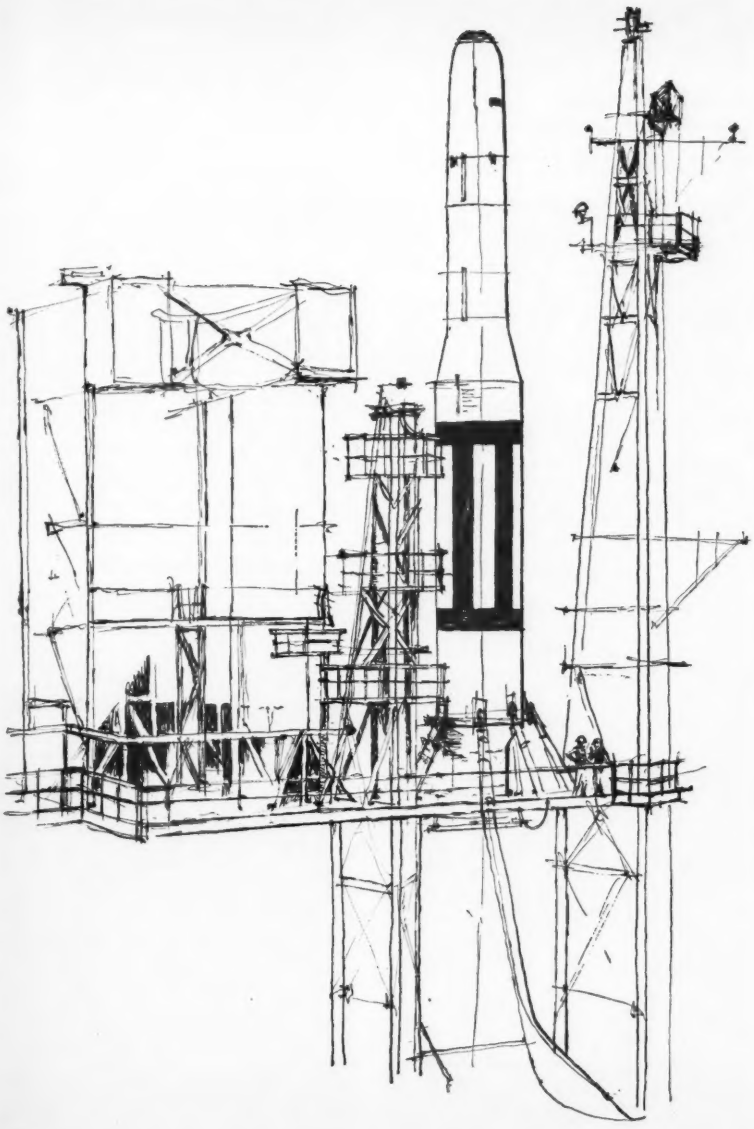
RADIO CORPORATION of AMERICA

DEFENSE ELECTRONIC PRODUCTS

CAMDEN, N. J.

Tmk(s) ®

There is nothing else like this under the sun. It is the Martin-Denver facility, birthplace of the Air Force TITAN. It is also this country's most advanced and fully integrated big-missile development center. Here, our most formidable weapon systems of tomorrow are being designed, built and tested—from the smallest component to the total system—within a single 7,000 acre complex. Every top military and scientific expert who has seen Martin-Denver from *within*, considers it one of our most valuable national resources.



MARTIN
BALTIMORE·DENVER·ORLANDO

TR 58-90) [*AD162122*], May 31, 1958. 44 pp. 19 refs.

Optimum Filter Functions for the Detection of Pulsed Signals in Noise. H. S. Heaps. *Can. J. Phys.*, June, 1958, pp. 692–703. Discussion of an optimum method for processing a signal received upon a background of noise.

Atmospheric Radio Noise at Frequencies Between 10 KC/S and 30 KC/S. Appendix—**Theoretical Relationships Between Impulse Peak Distribution and Other Parameters.** J. Harwood. (*IEE Paper 2619 R.*) *IEE Proc., Pt. B*, May, 1958, pp. 293–300.

Uniform Transient Error. E. L. R. Corliss. *J. Res.*, July, 1958, pp. 25–30. USAF-Navy-AEC-supported discussion on the economy of transient error. Transient limitations of a simple analyzer, analyzers made up of overlapped channels, and scanning analyzers are considered. The uniform transient error distribution and the limitation of noise are also described.

Shot Noise in p-n Junction Frequency Converters. A. Uhlir, Jr. *Bell System Tech. J.*, July, 1958, pp. 951–988. 17 refs. Army-supported analysis.

Distribution of the Duration of Fades in Radio Transmission: Gaussian Noise Model. S. O. Rice. *Bell System Tech. J.*, May, 1958, pp. 581–635. 15 refs.

Gain and Noise Figure of a Variable-Capacitance Up-Converter. D. Leenov. *Bell System Tech. J.*, July, 1958, pp. 989–1,008. Army-supported analysis.

Piezoelectricity

Piezoelectric Ceramics. Hans Jaffe. *Am. Ceram. Soc. J.*, Pt. II, Nov., 1958, pp. 494–498. Survey of piezoelectric crystals and presentation of new data on lead titanate zirconate over a range of compositions.

Telemetering Transducer Program. *Tech. News Bul.*, Oct., 1958, pp. 198–200. Discussion on the development of test methods pertinent to the selection, application, and improvement of transducers. The shock tube and the dual centrifuge are described.

Normal'nye Koordinaty Kristallicheskoi Reshetki pri Uchete Zapazdyvaniia Vzaimodeistviia. V. S. Mashkevich. *AN SSSR Dokl.*, July 11, 1958, pp. 247–249. In Russian. Derivation of normal coordinates of the crystal lattice with allowance for interaction lag.

Power Supplies

Precision Frequency Power from Missile Hydraulics Systems. H. J. Howard. *Auto. Control*, Aug., 1958, pp. 20–22. Discussion of the flexibility and weight-saving that can be obtained from integrating a.c. power and hydraulic systems in a single unit.

Designing Transistor D-C to A-C Converters. Stanley Schenkerman. *Electronics*, Sept. 26, 1958, pp. 78–80.

How to Regulate D-C Power with Transistors. R. T. Bayne and J. M. Buchanan. *Auto. Control*, July, 1958, pp. 6–9.

Radar

You Can Build in Radar Ground Mapping Resolution. R. H. Laprade and R. S. Timm. *Space/Aeronautics*, Oct., 1958, pp. 158–163. Optimization of design criteria for improved radar mapping.

Accurate Method for Correction of Slant Range Distortion in High-Altitude Radars and a Contribution to the Optics of Reflecting Conical Surfaces. Appendix I—**Derivation of Laws of Reflection of Skew Rays Reflected from Conical Surface.** Appendix II—**Blurring Resulting from the Inclination of the Strip Image at the Cone Axis with Respect to the Principal Plane (Angle α).** Leo Levi. *OSA J.*, Oct., 1958, pp. 680–686.

Raketenerfassung mittels Weitestradar. Karl Röhrich. *ZFW*, Sept., 1958, pp. 266–271. 11 refs. In German. Investigation on the possibilities of radar techniques to detect intercontinental ballistic missiles to ranges up to 4,800 km.

Radar in the Space Age. L. C. Van Atta. *IAS Natl. Summer Meeting, Los Angeles, July 8–11, 1958, Paper.* 7 pp. Exploration of the interactions between flight technology and radar technology. Flight paths, vehicle characteristics, and physical environment are considered; the implications for radar development and design are deduced.

Reliability

Vibration Equipment Survey. R. E. Shafer. *Electronic Des.*, Oct. 15, 1958, pp. 22, 23. Survey of possible vibration effects in equipment and of means to avoid them.

Semiconductors

The Diffusion Constant, Mobility and Lifetime of Minority Carriers in Germanium Containing Parallel Arrays of Dislocations. J. B. Arthur,

A. F. Gibson, J. W. Granville, and E. G. S. Paige. *Philos. Mag., 8th Ser.*, Sept., 1958, pp. 940–949.

Distribution of Magnetic Induction in the Intermediate State of a Current-Carrying Superconductor. B. V. Makei. (*Zhurnal Teoret. i Exper. Fis.*, Feb., 1958, pp. 312–315.) *Sov. Phys.-JETP*, Aug., 1958, pp. 217–219. Translation.

High Power Transistor Switches. J. L. Nelson. *Electronic Des.*, Nov. 12, 1958, pp. 36–39. Analysis of the operation of the transistor switching circuit and development of a design procedure. This includes the effect of high-temperature operation and the thermal properties of the transistor.

Composite-Transistor Offers High Gain. P. J. Klass. *Av. Week*, Aug. 25, 1958, pp. 53–57, 60.

Telemetry

A Bibliography of Telemetry. M. V. Kiebert. *IRE Trans., TRC Ser.*, June, 1958, pp. 10–19. 534 refs.

A Survey of Progress Reported in 1956 and 1957 in Telemetry and Remote Control. F. E. Rock. *IRE Trans., TRC Ser.*, June, 1958, pp. 2–9. 160 refs.

High Acceleration Telemetry Beats State of the Art. T. D. Horning. *Space/Aeronautics*, Oct., 1958, pp. 136, 137, 140–145. Discussion of high acceleration telemetry and of the problems encountered.

Application of the Phase-Locked Loop to Telemetry as a Discriminator or Tracking Filter. C. E. Gilchriest. *IRE Trans., TRC Ser.*, June, 1958, pp. 20–35.

Space Ship Telemetry. H. Scharla-Nielsen. *IRE Trans., TRC Ser.*, June, 1958, pp. 36–39. Presentation, in nomogram form, of some basic design information regarding telemetry over vast distances, and speculation on anticipated extensions.

Transmission Lines

The Nonuniform Transmission Line as a Broadband Termination. Ira Jacobs. *Bell System Tech. J.*, July, 1958, pp. 913–924. 10 refs.

The Effects of Mode Filters on the Transmission Characteristics of Circular Electric Waves in a Circular Waveguide. W. D. Warters. *Bell System Tech. J.*, May, 1958, pp. 657–677.

Normal Modes Methods for Boundary-Excited Wave Guides. Jean Van Bladel. *ZAMP*, Sept. 25, 1958, pp. 193–202. Solution of the boundary excitation problem by normal mode procedures.

Circular Waveguide Taper of Improved Design. Hans-Georg Unger. *Bell System Tech. J.*, July, 1958, pp. 899–912.

Research Models of Helix Waveguides. C. F. P. Rose. *Bell System Tech. J.*, May, 1958, pp. 679–688.

Wave Propagation

Propagation of Very-Low-Frequency Pulses to Great Distances. J. R. Wait. *J. Res.*, Sept., 1958, pp. 187–203. Analysis in which the space between the earth and the ionosphere is represented as a wave guide with sharply bounded and concentric spherical surfaces.

Transmission and Reflection of Electromagnetic Waves in the Presence of Stratified Media. J. R. Wait. *J. Res.*, Sept., 1958, pp. 205–232. 15 refs. Development of a general analysis for the electromagnetic response of a plane stratified medium consisting of any number of parallel homogeneous layers. The solution is first developed for plane-wave incidence and then generalized to both cylindrical and spherical-wave incidence.

Correlation Function and Power Spectra of Scatter Propagation Links for Arbitrary Inputs. D. S. Bugnolo. *Columbia U. Dept. Elec. Eng. Sch. Eng. TR T-1/C* (*AFOSR TN 58-463*) [*AD 158270*], June 2, 1958. 13 pp.

Measuring Microwave Interference. I. Robert Saul. *Electronic Des.*, Oct. 15, 1958, pp. 26–29. Discussion of interference and susceptibility measuring methods and systems.

Equipment

Electric

Discriminator Controls Aircraft Alternator. Roger Hill. *Electronics*, Oct. 10, 1958, pp. 94, 95. Discussion of a servo discriminator which measures phase with respect to preadjusted components, and thereby makes accuracy a function of initial setting.

Frequency-Regulated Hydroelectric Missile Power Supply. R. T. Ellis and T. W. Sheppard. (*Quart. Rev. Bumblebee Activ.*, July-Dec., 1957.) *The Johns Hopkins U., APL BB Rep. 274*, 1958, pp. 1–5. Description of the power supply system, the system parameters, and performance characteristics. Some engineering modifications are discussed.

Liquid-Cooled Generators for Mach I+. D. A. Wilhelmson. *Space/Aeronautics*, Nov., 1958, pp. 64–69.

Mechanical Alternator Drive Saves Weight and Fuel. John McGraw. *Space/Aeronautics*, Nov., 1958, pp. 44–48. Description and operation of mechanical friction drives; their possibilities are discussed.

Hydraulic & Pneumatic

Hydraulics—Contamination Control. J. H. Boucher. *Aircraft & Missiles Mfg.*, Oct., 1958, pp. 46–48. Description of filtering systems used in hydraulic control systems of the F8U Crusader.

Pneumatic Actuating System for 1000°F Operation. J. A. Osterman. *CAI-IAS Joint Meeting, Ottawa, Oct. 7, 8, 1958, Preprint 845.* 5 pp. Members, $0.35; nonmembers, $0.75. Study of a program to determine the feasibility of high-temperature pneumatics and to design an aircraft speed-brake servosystem.

Mekhanicheskaia i Khimicheskaia Stoikost, Zhidkostei Samoletnykh Gidrosistem. T. Bashta. *Grazhdanskaia Aviatsiia*, Aug., 1958, pp. 20, 21. In Russian. Discussion of the mechanical and chemical stability of hydraulic fluids in airborne equipment under varying environmental conditions.

A Test Program for Hydraulic Jacks. Ron Mason. *Ind. Aeronautics*, June, 1958, pp. 14–17.

Pneumatic Motors for Aircraft Actuation Systems. E. J. Knight, Jr. *Aero/Space Engrg.*, Dec., 1958, pp. 44–47. Discussion of the advantages of pneumatics for operation in adverse environments. A description of a positive-displacement pneumatic motor utilizing a nonexpansion hot gas cycle and an analysis of its performance are given.

Fuels & Lubricants

Ramjet Fuels: A Brief Survey. W. G. Berl and W. T. Renich. (*ARS 12th Annual Meeting, New York, Dec. 2–5, 1957.*) *Astronautics*, Sept., 1958, pp. 36, 37, 68. Survey of possible nonorganic fuel for ram-jet application.

USAF Developing High Temperature Oils. Michael Yaffee. *Av. Week*, Sept. 29, 1958, pp. 51–59. Discussion of a developmental program for lubricants to be used in advanced jet engines. Emphasis is placed on the use of synthetics, and the ultimate requirement is a radiation resistant lubricant capable of operating at 1,000°F.

Vliianie Teplovogo Effekta na Viazkoe Soprotivlenie v Ustanovivshemsia Odnomernom Techenii Kapel'noi Zhidkosti. S. A. Regirer. *Prikl. Mat. i Mekh.*, May-June, 1958, pp. 414–418. In Russian. Determination of the effect of heat on viscous strength in stationary one-dimensional flow of liquid between two infinite cylindrical surfaces.

Lubrication as a Load-Limiting Factor in Gearing. G. Niemann and H. Rettig. (*VDI Bericht No. 29*, 1957, pp. 133–140.) *Gt. Brit., RAE Lib. Transl. 760*, Aug., 1958. 19 pp.

Friction and Wear with Reactive Gases at Temperatures up to 1,200°F. G. P. Allen, D. H. Buckley, and R. L. Johnson. *U.S., NACA TN 4316*, Sept., 1958. 26 pp. 19 refs. Study of the boundary lubrication of metal surfaces with gases containing chlorine or sulfur at temperatures between 75°F. and 1,200°F.

Old Problems for Big Solid Rockets. C. D. McKinney, Jr., and L. E. Morey. *Astronautics*, Sept., 1958, pp. 31–33, 92, 93. Discussion of propellant geometry and physical properties as they affect performance, reliability, simplicity of manufacturing and maintenance, safe operation, and ready time.

Cold Propellants for Hot Performance. J. L. Sloop. *Astronautics*, Sept., 1958, pp. 28–30, 96, 97. Study of cryogenic liquids as propellants which indicates a high specific impulse, but poses problems in storage and handling resulting from their toxicity and uncompromising physical characteristics.

Free Radicals for High Energy Fuels. D. E. Carr, H. M. Fox, and E. D. Guth. *Space/Aeronautics*, Oct., 1958, pp. 22, 23, 191. Discussion on the practical problems to be solved when using free radical propellants; their production and storage are described.

Dark Horse in the Propellant Race. J. D. Clark. *Astronautics*, Sept., 1958, pp. 34, 35, 86. Discussion of the properties and advantages of monopropellants over other types of rocket propellants.

I_{sp}: How High for Chemical Fuels? J. M. Carter. *Astronautics*, Sept., 1958, pp. 26, 27, 74–76. Discussion of various methods for increasing specific impulse of fuels. It is concluded that the actual factors to be maximized are initial heat content per unit weight and the fractional conversion of this heat which calls for a maximum isentropic expansion exponent.

Ice Formation & Prevention

Aircraft Ice Protection. E. O. Robertson. *The Engr.*, June 20, 1958, pp. 928–931. Description of ice detection systems and de-icer controllers.

Development of Ice Protection Control Systems. E. O. Robertson. *Can. Aircraft Ind.*, Sept., 1958, pp. 10–12, 32–35. Discussion of de-icing control systems, with emphasis on electrothermal de-icing.

Solutions for Helicopter Rotor Blade Icing. D. A. Richardson, H. A. Wahl, and J. M. Clifford. (*IAS 26th Annual Meeting, New York, Jan. 27–30, 1958, Preprint 810.*) *AHS J.*, July 1958, pp. 3–9.

Instruments

An Optical System for the Study of Ultrasonic Waves. E. G. D. Youngs. *Marconi Rev.*, 2nd Quart., 1958, pp. 76–90.

A Microwave Spectrometer for the Study of Free Radicals. I. R. Hurle and T. M. Sugden. *J. Sci. Instr.*, Sept., 1958, pp. 319–323. 12 refs.

An Airborne Infra-Red Solar Spectrometer. J. T. Houghton, T. S. Moss, and J. P. Chamberlain. *J. Sci. Instr.*, Sept., 1958, pp. 329–333.

La Fabrication des Instruments de Bord sous Licence Anglo-Saxonne, dans les Pays Utilisant le Système Métrique. Antonio Sanchez. *Tech. & Sci. Aéronautiques*, Feb., 1958, pp. 33–37. In French. Discussion of methods for manufacturing aircraft instruments under Anglo-Saxon licence in countries using the metric system, and analysis of these procedures, including a tabulation of tolerances and conversions.

Theory of Oscillation Type Viscometers. III—A Thin Disk. A. G. Azpeitia and G. F. Newell. *ZAMP*, Sept. 25, 1958, pp. 97–118. AFOSR-supported analysis of the small amplitude oscillation of a thin disc of finite radius suspended in an "infinite" fluid with a view toward its use as a viscometer.

Flow Measuring Devices

The Measurement of Turbulent-Boundary-Layer Shear Stress by Means of Surface Impact-Pressure Probes. F. W. Fenter and C. J. Stalmach, Jr. *J. Aero/Space Sci.*, Dec., 1958, pp. 793, 794.

Interference Effects Among Static-Pressure Probes in Supersonic Flow. J. L. Lindsey. (*Quart. Rev. Bumblebee Activ.*, July-Dec., 1957.) *The Johns Hopkins U., APL BB Rep. 274*, 1958, pp. 17–20. Establishment of the minimum critical spacing for no mutual interference between individual probes, and determination of the severity of the interference caused by probes which are closer together than the minimum critical spacing.

The Design of an Acceleration Insensitive Skin Friction Balance for Use in Free Flight Vehicles at Supersonic Speeds. W. C. Lyons, Jr. *Texas U. Bur. Eng. Res., Henry Beckman Conserv. Bul. 2*, June 1, 1958, pp. 1–15. Navy-supported description of a device which is insensitive to inertial forces, but will respond to shear forces. Proving flights have been made in the Aerobee-Hi and Viking rockets.

Free-Flight Skin-Friction Measurements. F. W. Fenter and W. C. Lyons, Jr. (*Quart. Rev. Bumblebee Activ.*, July-Dec., 1957.) *The Johns Hopkins U., APL BB Rep. 274*, 1958, pp. 6–16. Presentation of skin-friction data from the Aerobee-Hi flight tests, and description of various evaluation tests to which the skin-friction balances were subjected to determine their suitability for flight test use.

The Measurement of Local Turbulent Skin Friction at Supersonic Speeds by Means of Surface Impact Pressure Probes. F. W. Fenter and Ch. J. Stalmach, Jr. *Texas U. DRL Rep. 392 (CM-878)*, Oct. 21, 1957. 55 pp. 26 refs. Discussion of an experimental program involving both surface impact pressure measurements and direct measurements of the local shear stress in the turbulent boundary layer on an isobaric surface.

Measurement of Skin Friction by Surface Impact Pressure Probes. F. W. Fenter and Ch. J. Stalmach, Jr. (*Quart. Rev. Bumblebee Activ.*, July-Dec., 1957.) *The Johns Hopkins U., APL BB Rep. 274*, 1958, pp. 41–49. Presentation of a simple method for measuring the shear stress in turbulent boundary layers; the principles established by more cumbersome methods are briefly discussed. Tests are described and results given.

Gyroscopes

K Teorii Slozhnykh Sistem Giroskopicheskoi Stabilizatsii. A. Iu. Ishlinskii. *Prikl. Mat. i Mekh.*, May-June, 1958, pp. 359–373. In Russian. Discussion covering the basic concepts of the theory of gyroscopic stabilization and presentation of a method for the derivation of equations of motion, based on Lagrange's approach.

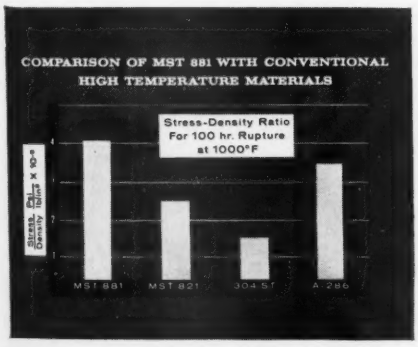
O Giroskope v Kardanovom Podvese. N. G. Chetaev. *Prikl. Mat. i Mekh.*, May-June, 1958, pp. 379–381. In Russian. Study of the motion of a symmetrical gyroscope on a gimbal support.

Ob Ustoichivosti Dvizheniia Giroskopa v Kardanovom Podvese. V. V. Rumiantsev. *Prikl. Mat. i Mekh.*, May-June, 1958, pp. 374–378. In Russian. Study covering the stability of motion of gyroscopes on gimbal supports. Includes derivation, based on Liapunov's function, of a sufficient stability condition, in particular, for the vertical position of the gyroscope axis.

New Mallory-Sharon 1100° Titanium Alloy

MST 881

BREAKS THE HEAT BARRIER


COMPARISON OF MST 881 WITH CONVENTIONAL HIGH TEMPERATURE MATERIALS
Stress-Density Ratio For 100 hr. Rupture at 1000°F
Stress/Density (lbs/in² x 10⁻³)
MST 881
MST 821
304 ST
A 286

Note high stress/density ratio of MST 881 at 1000° F., compared to MST 821 alloy, 304 and A 286 stainless steels.

Now, after 2½ years of intensive research, Mallory-Sharon has developed a new titanium alloy with elevated temperature properties far surpassing those of any existing titanium alloys.

At a temperature of 1000 degrees F., a level of increasing importance in the aircraft industry, MST 881 has *more than twice the creep strength* of any existing commercial titanium alloy. Even at 1100 degrees F., MST 881 will have only about 0.5% deformation at a stress of 25,000 psi.

What this means in terms of jet engine construction, for example, is illustrated above. The weight-saving advantages of titanium can now be obtained in additional stages of hot Mach 3 engines through use of MST 881.

Write today for technical data sheet on MST 881.

MALLORY SHARON

MALLORY-SHARON METALS CORPORATION • NILES, OHIO

O Dvizhenii Girostabilizirovannoi Platformy, Ustanovlennoi v Bikardanovom Podvese. N. T. Kuzovkov. *AN SSSR Otd. Tekh. Nauk Izv.*, July, 1958, pp. 94–97. In Russian. Application of previously obtained results to calculate the motion of gyrostabilized platforms on a gimbal support.

Pressure Measuring Devices

Simple Shielded Total-Pressure Probes. F. A. L. Winternitz. *Aircraft Eng.*, Oct., 1958, pp. 313–317. 10 refs. Comparison of design features and characteristics of conventional, modified, and shielded total-pressure probes with new shielded instruments of simple construction which combine smallness of size with adequately fast response to pressure changes.

Manomètre à Très Large Bande de Fréquence et Applications aux Mesures de Pressions Rapidement Variables. P. Lienard. (*NATO AGARD Wind-Tunnel & Model-Testing Panel, London, Mar. 24–28, 1958.*) *NATO AGARD Rep. 170*, Mar., 1958. 15 pp. In French. Discussion on the use of measuring devices developed from microphones as manometers in aeronautical research. The characteristics required for the manometers, the measurement principles, and their applications are described.

Sonde Tridimensionnelle pour Turbo-Machines. F. Charron. *La Recherche Aéronautique*, July-Aug., 1958, pp. 17, 18. In French. Description of a three-dimensional pressure gage for measuring turbine flow.

Recording Equipment

A New Airborne Profile Recorder. W. V. O'Leary. *Can. Aircraft Ind.*, Aug., 1958, pp. 14–19.

The Use of Oscillographs in Aviation Testing. *Ind. Aeronautics*, June, 1958, pp. 18–26.

Stress & Strain Measuring Devices

Strain Gages—Their Use in Airplane Stress Analysis. C. R. Smith. *Ind. Labs.*, Sept., 1958, pp. 104–107. Discussion on the applications of strain gages (a) to check stress analysis, (b) as a safety valve during static tests to avert premature failure, and (c) as a means of monitoring loads.

High-Temperature Strain Gages. *Tech. News Bul.*, July, 1958, pp. 134–137.

Precision Strain Gauge Techniques. A. Tiffany and J. Wood. *Electronic Eng.*, Sept., 1958, pp. 528–535. Review of strain gage techniques for use with automatic digital equipment.

Pretsizionnyi Elektricheskii Tenzometr dlia Izmereniia Poperechnykh Deformatsii. A. V. Gur'ev. *Izmer. Tekh.*, July-Aug., 1958, pp. 31, 32. In Russian. Description of a strain gage designed to measure lateral deformation in metals.

Evaluation of Stress-Strain Recorders. *Tech. News Bul.*, Sept., 1958, pp. 172–174. Discussion of the calibration, resolution, averaging ability, and load response of an extensometer.

Tachometers

For Measuring RPM—Which Tachometer. H. D. Drage. *Prod. Eng.*, Nov. 10, 1958, pp. 89–92.

Temperature Measuring Devices

High - Temperature Measurements. *Tech. News Bul.*, July, 1958, pp. 125–130. Description of instruments for high-temperature measurements; improvements in design and methods of application are discussed.

Thermal Transducers. M. Kovarik. *Australian J. Appl. Sci.*, Sept., 1958, pp. 225–235.

Vibration Measuring Devices

A Vibration Pick-Up Which Does Not Load the System Being Examined. S. K. Rushforth and A. Selwood. *J. Sci. Instr.*, Sept., 1958, pp. 340–343. Description of a device that measures the amplitude and indicates the phase of vibration of a structure without touching or loading it in any way.

Laws & Regulations

Diritto Spaziale o Astronautico. Amedeo Giannini. *Riv. Aero.*, Sept., 1958, pp. 1,293–1,302. In Italian. Discussion covering various legal aspects of space travel.

Machine Elements

Bearings

Recent Studies on Energy Losses in Roller Bearings. A. Palmgren. (*VDI Bericht No. 20*, 1957, pp. 117–121.) *Gt. Brit., RAE Lib. Transl. 759*, July, 1958. 9 pp.

Dynamic Measurement of Film-Thickness in Gas Bearings. J. Schutten, H. Baron, T. Van Der Hauw, and P. J. Van Deenen. *Appl. Sci. Res., Sect. A*, No. 6, 1958, pp. 429–436. Description of a method to determine the position of the sliding part of a bearing and its vibration with an accuracy of about 0.1 μm. The design for a gas-lubricated journal bearing is discussed.

The Rectangular Plane Pad Bearing. Bengt Jakobsson and Leif Floberg. *Chalmers Tek. Högskolas Handlingar, No. 203*, 1958. 44 pp.

Rotating Discs & Shafts

On the Torsional Characteristics of a Shaft with Multi-Symmetrical Curved Boundary. D. R. Axelrad and A. Reichel. *Australian J. Appl. Sci.*, Sept., 1958, pp. 216–224.

Stresses in Rotating Thin Plates with Curvilinear Boundaries. G. M. Arkilic. *Franklin Inst. J.*, Oct., 1958, pp. 279–292. Presentation of a solution for the boundary stresses in thin curvilinear plates rotating with a constant velocity about an axis in the plane of the plate.

Maintenance

Special Issue: ATA 1958 Annual Engineering and Maintenance Conference. *Douglas Serv.*, Sept.-Oct., 1958, pp. 1–47. *Partial Contents:* Prevention of Fuel System Icing. Investigation of Aluminum Wire Terminals. Propeller Reverse Switch Rigging. DC-7C Landing Gear Wheels and Brakes. Overloading of Nose Gear by Towing. Deterioration of Cabin Supercharger Bridle Circuit Hose. Landing Gear. Hydraulic High-Pressure Hose. DC-7C Cabin Soundproofing Improvements. DC-6/7 Series Structural Design Trends. DC-7 Series Elevator Torque Tube Support Bracket Wear. DC-7 Series Rudder Control Torque Tube Wear. Prevention of Damage to Antidrag Rings. Deletion of Instrument Panel Shock Mounts. DC-7 Series Water System Freezing. Water Heater Problems and Improvements.

Materials

Special Issue: Materials Selector. *Materials in Des. Eng.*, 1958-59. 350 pp. Comprehensive guide to manufacturers and products covering various types of materials, their properties, forms, and joining and fastening.

Ceramics & Ceramals

Ceramic Materials—Properties for Structural Applications. W. J. Knapp and F. R. Shanley.

HIGH TEMPERATURE CAPACITORS BY BENDIX

The *E*-315 capacitor offers proven stability of operation over the temperature range of −55° to +315° Centigrade* with no voltage derating and low capacitance variation. Of rugged hermetically sealed construction and nonstrategic materials, this capacitor is built for high altitude and severe environmental operation.

This nonpolarized capacitor is available in a variety of sizes in a capacity range of from 0.05 to 4.0 microfarads at 600 VDC. It is also available in higher voltage ratings. Performance data and operating characteristics are given in Technical Bulletin SL-61 which is supplied upon request.

*Confirmed by qualification test of 1000 hours at 100% rated voltage over ambient temperature range of −55° to +315° C.

Now Available in Production Quantity

E-315

DESIGN FEATURES

Temperature Range . . . −55° to +315°C. Capacitance . . . 0.05 to 4.0 uf at 600 VDC. Voltage Range . . . 600 V to 3000 V per section. No Voltage Derating, Low Capacitance and Power Factor Variation, Environmental Resistant, Hermetically Sealed, Rugged Construction, Nonstrategic Materials, Minimum Size and Weight, High Altitude Operation.

Canadian Affiliate: Aviation Electric Ltd., 200 Laurentien Blvd., Montreal 9, Quebec.
Export Sales and Service: Bendix International Division, 205 East 42nd St., New York 17, N.Y

Scintilla Division
Sidney, New York

Bendix AVIATION CORPORATION

Aero/Space Engrg., Dec., 1958, pp. 34–38. 12 refs. Review of the general characteristics of elastic and plastic deformation of ceramic materials. At room temperature crystalline ceramics undergo essentially elastic deformation only, while at high temperatures plasticity and creep may be evident. It appears that failures of ceramics under static and dynamic loadings are chiefly tensile in character. This behavior seems to be closely related to the lack of plasticity of ceramics at room temperature.

Investigation of Ceramic Materials in a Laboratory Rocket Motor. J. F. Lynch, J. F. Quirk, and W. H. Duckworth. (*Am. Ceram. Soc. 59th Annual Meeting, Dallas, May 8, 1957.*) *Am. Ceram. Soc. Bul.*, Oct., 1958, pp. 443–445. Evaluation of 34 different ceramic materials as nozzle liners in a laboratory rocket motor employing a hydrogen-oxygen propellant system.

High-Temperature Mechanical Properties of Ceramic Materials. I—Magnesium Dititanate. E. A. Bush and F. A. Hummel. *Am. Ceram. Soc. J.*, June, 1958, pp. 189–195. 30 refs.

Porcelain Enamels and Ceramic Coatings. R. J. Fabian. *Materials in Des. Eng.*, July, 1958, pp. 103–106, 108–111, 113–118. Survey of main types of coatings available, and presentation of data on engineering properties, principal metals that can be coated, coating selection, and design factors.

Thermal Insulation Ceramic Coatings. A. V. Levy. *CAI-IAS Joint Meeting, Ottawa, Oct. 7, 8, 1958, Preprint 857.* 7 pp. Members, $0.35; nonmembers, $0.75. USAF-supported development of two types of coatings which have successfully withstood temperatures of 3,000°F. and above, markedly reducing the operating temperature of the metal components upon which they were applied. The first type is a flame sprayed ceramic oxide, and the other is a metal-reinforced ceramic, applied by troweling a ramming mix into a metallic matrix that is attached to the structural base metal.

Problems in Simultaneous Heat-Hardening and Ceramic Coating of No. 420 Stainless Steel. E. L. Bradley. (*Am. Ceram. Soc. 59th Annual Meeting, Dallas, May 5–9, 1957.*) *Am. Ceram. Soc. Bul.*, May, 1958, pp. 222–226.

Evaluation of Tensile, Compressive, Torsional, Transverse, and Impact Tests and Correlation of Results for Brittle Cermets. M. J. Kerper, L. E. Mong, M. B. Stiefel, and S. F. Holley. *J. Res.*, Sept., 1958, pp. 149–169. 43 refs.

Ceramic Honeycomb. *Aircraft & Missiles Mfg.*, Nov., 1958, pp. 24, 25. Discussion on the properties and applications of Cercor, a structural material to be used where aerodynamic heating is a problem.

Corrosion & Protective Coatings

A Guide to Materials Standards and Specifications. VI—Finishes and Coatings. S. P. Kaidanovsky. *Materials in Des. Eng.*, Aug., 1958, pp. 101–103.

The Effect of Wetting; The Influence of Non-Corrosive Liquids on the Strength of Solid Bodies. Carl Benedicks. (*Rev. Metall.*, No. 1/2, 1948, pp. 9–18.) *Gt. Brit., RAE Lib. Transl. 758*, July, 1958. 18 pp. 37 refs.

Erosion Damage to Solids Caused by High-Speed Collision with Rain. O. G. Engel. *J. Res.*, July, 1958, pp. 47–52. USAF-sponsored investigation.

Compatibility of Metals with Liquid Fluorine at High Pressures and Flow Velocities. H. W. Schmidt. *U.S., NACA RM E58D11*, July 15, 1958. 15 pp. Study of various metals in selected geometric configurations exposed to liquid fluorine. None of the metal samples eroded, decomposed, or exhibited any measurable physical or chemical changes. In a run made with a Teflon sample, instantaneous chemical reaction and decomposition occurred.

High Temperature

Materials and Processes for the Hot Airplane. H. B. Sipple and G. G. Wald. *Ind. Aeronautics*, June, 1958, pp. 25–28, 31. Discussion of the development, production, and application of new materials for supersonic manned vehicles.

Limit Design for Economical Missile Structures. L. A. Riedinger. *Space/Aeronautics*, Oct., 1958, pp. 32, 33–39 (ff). Discussion of design approaches for producing lightweight, high temperature missile structures.

Metals & Alloys

7 Closer Looks at Metal Properties. Edward Loria. *Prod. Eng.*, Oct. 27, 1958, pp. 48, 49. Discussion of some mechanical properties as they affect design conditions. These include strain rates; transverse properties; compressive, fatigue, and tear strengths, biaxial stresses, and surface defects.

Behavior of Certain Alloys Subjected to Dynamic Loading. R. G. Crum and F. T. Mavis. *ASTM Bul.*, July, 1958, pp. 88–91. Test results on steel, aluminum, and titanium alloys showing that the yield and ultimate strength are greater for dynamic loading than for static loading.

Recovery of Damping and Modulus Changes Following Plastic Deformation. A. Granato, A. Hikata, and K. Lücke. *Acta Metallurgica*, July, 1958, pp. 470–480. 28 refs. USAF-Army-supported development of a theory which assumes that changes with time in the decrement and modulus of a crystalline material following plastic deformation are a result of dislocation pinning by deformation.

Neravnomermosti Plasticheskoi Deformatsii Kristallov. V. N. Rozhanskii. *Uspekhi Fiz. Nauk*, July, 1958, pp. 387–406. 151 refs. In Russian. Study of the inhomogeneity of plastic deformation in solid bodies, with emphasis on the formation of microscopic cracks.

Pseudospirals, Imperfect Structures and Crystal Habit Produced by Field Evaporation of Metal Crystals. E. W. Müller. *Acta Metallurgica*, Oct., 1958, pp. 620–630. 16 refs. AFOSR-supported investigation.

Raschet Predel'nykh Znachenii Energii Aktivatsii Razlichnykh Protsessov v Tverdykh Metallakh. K. A. Osipov. *AN SSSR Dokl.*, Aug. 1, 1958, pp. 637–639. In Russian. Calculation of boundary values for the activation energy of various processes in solid metals.

The Temperature Dependence of the Flow Stress of an Age-Hardened Alloy. A. Kelly and C. Chiou. *Acta Metallurgica*, Sept., 1958, pp. 565–571. 27 refs. AFOSR-sponsored research.

Some Corrosion Fatigue Observations on High Purity Aluminium-Zinc-Magnesium Alloy and Commercial DTD 683. C. A. Stubbington and P. J. E. Forsyth. *Gt. Brit., RAE TN Met. 289*, May, 1958. 29 pp.

Some Observations on the Fatigue Behaviour of Aluminium-7% Magnesium in Various Conditions of Heat Treatment. C. A. Stubbington. *Metallurgia*, Oct., 1958, pp. 165–171.

Some Observations Relating to Recovery of Internal Friction During Fatigue of Aluminum. S. R. Valluri. *U.S., NACA TN 4371*, Sept., 1958. 30 pp. 11 refs. Experimental results indicate that obtaining a recovery factor independent of stressing history may possibly be associated with installing a cyclic process in which the subgrain structure is well established.

Cumulative Fatigue Damage at Elevated Temperature. W. K. Rey. *U.S., NACA TN 4284*, Sept., 1958. 53 pp. 37 refs. Study of cumulative fatigue damage using SAE 4130 steel. The S-N curves at room temperature, 400°F., and 800°F. are obtained from rotating-beam fatigue tests and compared with theoretical analyses.

Staticheskie Uprugo-Plasticheskie Deformatsii pri Mnogokratnykh Tsiklicheskikh Nagruzheniiakh. V. V. Moskvitin. *AN SSSR Otd. Tekh. Nauk Izv.*, July, 1958, pp. 24–32. In Russian. Determination of static elasto-plastic deformations of metals in the case of recurrent cyclic loads.

Effects of High Temperatures on Nickel-Copper Tensile Properties. *Tech. News Bul.*, Aug., 1958, pp. 152, 153.

Pure Torsion Creep Tests on Magnesium Alloy (2% Al) at 20°C., and on 0.2% C Steel at 450°C., at Low Rates of Strain (10^{-6} to 10^{-9} per hour). A. E. Johnson, J. Henderson, and V. D. Mathur. *Metallurgia*, Sept., 1958, pp. 109–117.

Au Sujet des Propriétés Mécaniques des Alliages Légers aux Basses, Moyennes et Hautes Températures; Domaine d'Utilisation à Chaud. M. Tournaire. *Tech. & Sci. Aéronautiques*, Dec., 1957, pp. 273–283. In French. Experimental determination of mechanical properties of light alloys at low, mean, and high temperatures. Includes tables listing the types and the chemical composition of light alloys used in aviation, specifying the temperatures for heat treatment of these alloys.

Diagrammy Sostav-Zharoprochnost' Splavov Troinoi Sistemy Titan-Vanadii-Niobii. V. S. Vlasov and I. I. Kornilov. *AN SSSR Otd. Tekh. Nauk Izv.*, July, 1958, pp. 136–139. In Russian. Study of the heat resistance for systems of ternary alloys (Ti-V-Nb).

Mechanism of Beneficial Effects of Boron and Zirconium on Creep-Rupture Properties of a Complex Heat-Resistant Alloy. R. F. Decker and J. W. Freeman. *U.S., NACA TN 4286*, Aug., 1958. 54 pp. 44 refs. Test results indicating that the additions improve the creep-rupture properties at 1,600°F. due to a stabilizing effect on the grain boundaries. These additions prolonged the life to fracture and allowed higher deformations before fracture.

Izuchenie Metodom Uprugikh Kolebanii Kinetiki Izmeneniia Svoistv Metallov i Splavov pri Nagreve. M. G. Lozinskii and A. E. Fedorovskii. *AN SSSR Otd. Tekh. Nauk Izv.*, June, 1958, pp. 19–29. 19 refs. In Russian. Survey of dynamic methods for measuring the variation of the modulus of elasticity and internal friction in metals and alloys, discussion of their application, and presentation of experimental results.

301 Stainless Modified for 800 deg F and Up. D. B. Roach, A. M. Hall, R. Sergesen, and A. R. Stargardter. *Space/Aeronautics*, Oct., 1958, pp. 58–63.

Influence of Hot-Working Conditions on High-Temperature Properties of a Heat-Resistant Alloy. J. F. Ewing and J. W. Freeman. *U.S., NACA Rep. 1341*, 1957. 52 pp. Supt. of Doc., Wash., $0.50.

Consider Cr-Mo-V Low Alloy Steels for 1000F Service. C. M. Cosman. *Materials in Des. Eng.*, Oct., 1958, pp. 93–96.

Slip Casting of Metals, Ceramics, and Cermets. P. E. Rempes, B. C. Weber, and M. A. Schwartz. (*Am. Ceram. Soc. 59th Annual Meeting, Dallas, May 8, 1957.*) *Am. Ceram. Soc. Bul.*, July, 1958, pp. 334–339. 40 refs. Discussion of the principles and problems in slip-casting nonplastic powders, including metals, carbons, cermets, oxides, carbides, borides, fluorides, and silicides.

High-Strength Steel. *Aircraft & Missiles Mfg.*, Nov., 1958, pp. 8–12. Discussion on the growing use of high strength steel in aircraft and missiles. The major classes of steel showing promise and their characteristics are described.

Which High Strength Steel? R. J. Nekervis, C. H. Lund, and A. M. Hall. *Materials in Des. Eng.*, July, 1958, pp. 84–89. Discussion of advantages and disadvantages of five new classes of steel, ranging from 150,000 to 310,000 psi.

Metals & Alloys, Nonferrous

A Review of Diffusion in Aluminium. J. W. H. Clare. *Metallurgia*, June, 1958, pp. 273–278. 31 refs.

Creep of Aluminum Under Extremely Small Stresses. J. G. Harper, L. A. Shepard, and J. E. Dorn. *Acta Metallurgica*, July, 1958, pp. 509–518. 16 refs.

Aluminum Sand Castings: How Well Do They Resist Repeated Impact and Fatigue at High Temperatures. W. J. Reichenecker and D. K. Fox. *Materials in Des. Eng.*, Oct., 1958, pp. 103–105.

O Temperaturnoi Zavisimosti Viazkosti Aliuminiia. V. M. Glazov and Iu. D. Chistiakov. *AN SSSR Otd. Tekh. Nauk Izv.*, July, 1958, pp. 141–143. In Russian. Investigation to determine the effect of temperature on the viscosity of aluminum.

Effect of Precipitate Particles on Creep of Aluminum-Copper Alloys During Age Hardening. E. E. Underwood, L. L. Marsh, and G. K. Manning. *U.S., NACA TN 4372*, Sept., 1958. 56 pp. 37 refs.

New Magnesium Alloys. R. J. M. Payne and N. Bailey. *Metallurgia*, Aug., 1958, pp. 67, 68. Discussion on the development of new magnesium alloys and their advantages.

Titanium. *Aircraft & Missiles Mfg.*, Nov., 1958, pp. 28–32. Discussion on the application of titanium to the Crusader series. Design and production techniques are described.

Crucible Steel Introduces Three New Heat-Treatable Titanium Alloys. *Ind. Labs.*, Aug., 1958, pp. 30, 31.

Effect of Strain-Temperature History on the Tensile Behavior of Titanium and a Titanium Alloy. G. W. Geil and N. L. Carwile. *J. Res.*, Sept., 1958, pp. 173–186. 10 refs. WADC-supported research.

Vliianie Vodoroda na Strukturu i Svoistva Titana i Ego Splavov. S. G. Glazunov, I. I. Kornilov, and A. M. Iakimova. *AN SSSR Otd. Tekh. Nauk Izv.*, June, 1958, pp. 30–36. 28 refs. In Russian. Brief survey of investigations covering the effect of hydrogen on the structure and properties of titanium and its alloys.

Nonmetallic Materials

Guide to Materials Standards and Specifications. V—Nonmetallics. S. P. Kaidanovsky. *Materials in Des. Eng.*, July, 1958, pp. 93–96.

Aircraft Timber. D. W. Richardson. *SLAE J.*, Aug., 1958, pp. 7–12. Discussion on the use of wood as a structural material for aircraft. Various timbers, their properties, and geographic distribution are described.

Report on the Third Biennial Carbon Conference, University of Buffalo, and on a Visit to the Fuel Technology Department, Pennsylvania State University. P. Webster. *Gt. Brit., RAE TN Met. 273*, Mar., 1958. 49 pp. 140 refs.

Sinteticheskie Materialy v Samoletostroenii. V. Tur'ian. *Kryl'ia Rodiny*, Aug., 1958, pp. 14, 15. In Russian. Discussion of the application of synthetic materials to aircraft structures.

Structural Asbestos Base Plastic Parts Resist—Burning Propellants—Aerodynamic Heat. D. V. Rosato. *ASME-ARS Joint Av. Conf., Dallas, Mar. 17–20, 1958, Preprint 589-58.* 14 pp.

Untersuchungen über die Verwendungsmöglichkeit von Glasfaser-Kunststoff für Segelflugzeug-Tragflügel. E. Ohlmer. *Luftfahrttechnik*, Sept. 15, 1958, pp. 252–257. In German. Investigation on the use of fiberglass materials for glider wings.

High-Temperature-Resistant Ceramic Adhesives. H. G. Lefort and D. G. Bennett. (*Am. Ceram. Soc. 59th Annual Meeting, Dallas, May 6, 1957.*) *Am. Ceram. Soc. J.*, Pt. I, Nov., 1958, pp. 476–482. USAF-supported development of ceramic adhesives for bonding metal in the operational range between 500°F. and 1,000°F.

Relationship of Metal Surfaces to Heat-Aging Properties of Adhesive Bonds. J. M. Black and

R. F. Blomquist. *U.S., NACA TN 4287*, Sept., 1958. 30 pp. 12 refs. Study to determine the probable causes of deterioration of each of several adhesives in bonds to stainless steel at temperatures from 400°F. to 550°F.

The Practical Determination of Strength of Aircraft Fabric with Dope Removed. A. L. Morse and J. H. Clark. *U.S., CAA TDR 333 (OTS PB 131639, $0.50.)*, Jan., 1958. 10 pp.

Friktsionnye Svoistva Kauchukopodobnykh Polimerov. G. M. Bartenev and Z. E. Styran. *AN SSSR Dokl.*, July 1, 1958, pp. 87–90. In Russian. Study of friction properties of rubber-like polymers.

Homogeneous Fiber-Polymer. N. L. Greenman. *Aircraft & Missiles Mfg.*, Oct., 1958, pp. 40, 41. Discussion of the special properties of Teflon coated ceramic fibers suitable for providing shields for re-entry. The process of forming from a water dispersion is also discussed.

Sandwichbauweise aus glasfaserverstärktem Kunstharz und Balsaholz. H. Nägele, R. Eppler, and H. Langer. *Luftfahrttechnik*, Sept. 15, 1958, pp. 258–262. In German. Discussion covering the fiberglass-reinforced and balsa-wood sandwich structures for glider application.

Tensile and Compressive Properties of Fiberglass Reinforced Laminates. R. E. Chambers and F. J. McGarry. *ASTM Bul.*, Oct., 1958, pp. 40–44.

Rheological Measurements for Characterising High Polymers. K. Edelmann and E. Horn. (*Gum. & Asb.*, No. 10, 1957, pp. 456–460.) *Gt. Brit., MOS TIL/T4890*, Aug., 1958. 10 pp. 11 refs.

Best Recipe for Casting Urethane Foam. Harry Gerstin. *Prod. Eng.*, Nov. 10, 1958, pp. 86–88.

Polyethylene Balloon Film. C. J. B. Thor. *Res. Rev.*, May, 1958, pp. 13–16. Discussion on the requirements and characteristics of the polyethylene balloon film; tests determining its acceptability are briefly described.

Testing Methods

A Disk Shear Test for Adhesives. S. B. Twiss and L. B. Clougherty. *ASTM Bul.*, Sept., 1958, pp. 57–61. Description of an apparatus for measuring the shear strength of adhesives in metal to metal bonding, which minimizes peeling stresses and permits measurements at elevated temperatures.

Microhardness Testing; Equipment, Techniques, Applications. V. E. Lysaght. *Tool Engr.*, Oct., 1958, pp. 87–90.

Mathematics

B—Angewandte Mathematik. (*GAMM Wissenschaftliche Tagung, Saarbrücken, Apr. 8–12, 1958.*) *ZAMM*, July-Aug., 1958, pp. 256–284. 32 refs. In German. *Partial Contents*: Ein Iterationsverfahren zur Approximation durch Polynome, W. Barth. Praktische Herleitung asymptotischer Darstellungen, Lothar Berg. Iterative Lösung von Funktionalgleichungen erster Art, Horst Bialy. Einige funktionalanalytische Methoden bei der numerischen Behandlung von Differentialgleichungen, L. Collatz. Interne Organisation eines kleinen programmgesteuerten Rechenautomaten, K.-J. Lesemann. Über die Lösung der Poissonschen Differenzengleichungen der Festigkeitslehre bei beliebigem Gebiet mit Hilfe der Hypermatrizenalgorithme von E. Egerváry, V. Lovass-Nagy. Gleichungsauflösung mittels einer speziellen Interpolation, Günter Opitz. Über eine Verallgemeinerung der Kettenbrüche, Heinz Rutishauser. Ein neues Verfahren zur unmittelbaren numerischen Lösung der Dirichletschen Randwertaufgaben, J. Szabó. Symposium of papers covering: an iteration method of approximation by means of polynomials, derivation of asymptotic representations, iterative solution of first-order functional equations, application of certain numerical methods to differential equations, design and operation of computers, solution of Poisson differential equations for a specific case, application of interpolation methods, generalization of periodic fractions, and methods for the numerical solution of Dirichlet boundary value problems.

A Subroutine Method for Calculating Logarithms. R. W. Bemer. *Assoc. Comp. Mach. Commun.*, May, 1958, pp. 5–7.

Novyi Metod Dokazatel'stva Teorem Nepolnoty dlia Sistem s Pravilom Karnapa i Ego Prilozhenie k Voprosu Vzaimootnosheniia Klassicheskogo i Konstruktivnogo Analizov. B. Ia. Falevich. *AN SSSR Dokl.*, June 21, 1958, pp. 1,210–1,213. In Russian. Development of a new method of proving incompleteness theorems for systems with Carnap rule, and application to the problem of interrelation between classical and constructive analyses.

Tables for the Numerical Calculation of Inverse Laplace Transforms. H. E. Salzer. *J. Math. & Phys.*, July, 1958, pp. 89–100.

Periodic Transformations and Fixed Point Theorems. I—Cup Products and Special Cohomology. S. D. Liao. *Scientia Sinica*, Aug., 1958, pp. 773–815. 13 refs. Study of the duality properties of manifolds affected by periodic transformations.

The Padé Table and the τ-Method. Y. L. Luke. *J. Math. & Phys.*, July, 1958, pp. 110–127. 24 refs. AFOSR-supported method of appraising the error incurred when approximating a given transcendental with a given number of terms. Closed form expressions for the error are derived, and it is shown how they may be used to appraise the error in a convenient manner.

On the Truncation Error in a Numerical Solution of the Neumann Problem for a Rectangle. J. H. Giese. *J. Math. & Phys.*, July, 1958, pp. 169–177. Application of the discrete Fourier analytic method to the Neumann problem for the rectangle R. Two explicit examples show how the nature of the approximation to the normal derivatives at the boundary affects convergence.

Zamechanie o Kriterii Petrovskogo Ravnomernoi Korrektnosti Zadachi Koshi dlia Uravnenii v Chastnykh Proizvodnykh. S. L. Sobolev. *AN SSSR Dokl.*, Aug. 1, 1958, pp. 598–601. In Russian. Evaluation of the Petrovsky criterion for the uniform correctness of the Cauchy problem in the case of partial differential equations.

A Method of Approximating the Complex Roots of Equations. Stephen Kulik. *Pacific J. Math.*, Summer, 1958, pp. 277–284.

The Solution of "Ill-Conditioned" Linear Simultaneous Equations; Methods for Reducing the Influence of Experimental Errors. J. W. Head and G. M. Oulton. *Aircraft Eng.*, Oct., 1958, pp. 309–312.

O Lineinykh Uravneniiakh v Chastnykh Proizvodnykh Beskonechnogo Poriadka s Postoiannymi Koeffitsientami. V. I. Protasov. *AN SSSR Dokl.*, Aug. 1, 1958, pp. 594–597. In Russian. Derivation of partial linear equations of infinite order with constant coefficients.

Ob Asimptoticheskom Povedenii Reshenii Sistem Lineinykh Uravnenii. M. A. Evgrafov. *AN SSSR Dokl.*, July 21, 1958, pp. 407–410. In Russian. Determination of the asymptotic behavior of solutions for systems of linear equations.

Remarks on the Maximum Principle for Parabolic Equations and Its Applications. Avner Friedman. *Pacific J. Math.*, Summer, 1958, pp. 201–211.

Uravneniia Parabolicheskogo Tipa s Razryvnymi Koeffitsientami. A. A. Samarskii. *AN SSSR Dokl.*, July 11, 1958, pp. 225–228. In Russian. Derivation of equations of the parabolic type with discontinuous coefficients.

On the Periodicity of the Solution of a Certain Nonlinear Integral Equation. Olavi Hellman. *Pacific J. Math.*, Summer, 1958, pp. 219–226. Army-Navy-sponsored study.

Ob Asimptoticheskom Povedenii Reshenii Raznostnykh Uravnenii. M. A. Evgrafov. *AN SSSR Dokl.*, July 1, 1958, pp. 26–29. In Russian. Evaluation of the asymptotic behavior of a solution for difference equations.

Nekotorye Svoistva Osobykh Integralov Tipa Koshi i Ikh Prilozheniia. V. V. Ivanov. *AN SSSR Dokl.*, Aug, 11, 1958, pp. 793, 794. In Russian. Determination covering certain properties of singular integrals of the Cauchy type and their application.

Lower Bounds for Higher Eigenvalues by Finite Difference Methods. H. F. Weinberger. *Pacific J. Math.*, Summer, 1958, pp. 339–368. 20 refs. Army-sponsored determination of the lower bounds for the eigenvalues of an arbitrary second-order self-adjoint elliptic differential operator on a bounded domain R with zero boundary conditions in terms of the eigenvalues of an associated finite difference problem. Self-adjoint systems of elliptic differential equations containing no mixed derivatives are also treated.

Opisanie Nekotorogo Klassa Predstavlenii Gruppy Lorentsa. D. P. Zhalobenko. *AN SSSR Dokl.*, Aug. 1, 1958. pp. 586–589. In Russian. Derivation of a partial solution for the problem covering the representation of a certain class of Lorenz group representations.

O Razlozhenii Neprivodimykh Predstavlenii Osnovnoi Serii Kompleksnoi Unimoduliarnoi Gruppy n-go Poriadka po Predstavleniiam Kompleksnoi Unimoduliarnoi Gruppy Vtorogo Poriadka. M. A. Naimark. *AN SSSR Dokl.*, Aug. 1, 1958, pp. 590–593. In Russian. Resolution of irreducible representations of the principal series of an nth-order complex unimodular group into representations of a second-order complex unimodular group.

On the Automorphisms of Linear Groups Over a Non-Commutative Principal Ideal Domain of Characteristic $\neq 2$. Wan Zhe-Xian. *Scientia Sinica*, Sept., 1958, pp. 885–933.

Ob Ortogonal'nykh Podgruppakh Klassicheskikh Kompaktnykh Grupp Li. A. M. Vasil'ev. *AN SSSR Dokl.*, July 1, 1958, pp. 18–21. In Russian. Analysis covering the orthogonal subgroups of classical compact Lie groups.

Ob Odnom Obshchem Sposobe Polucheniia Podgrupp i Faktorizatsii Konechnykh Grupp. S. A. Chunikhin. *AN SSSR Dokl.*, July 11, 1958, pp. 243–245. In Russian. Development of a method for obtaining subgroups and factorizations of finite groups.

The Structure of Idempotent Semigroups. I. Naoki Kimura. *Pacific J. Math.*, Summer, 1958, pp. 257–275. Study of regular idempotent semigroups. The problem of determining the conditions for identities to be equivalent to rectangularity is discussed. Characterizations of identities for some special idempotent semigroups are obtained.

Maksimal'nyi Koeffitsient Korreliatsii (Nesimmetrichnyi Sluchai). O. V. Sarmanov. *AN SSSR Dokl.*, July 1, 1958, pp. 52–55. In Russian. Derivation of the maximum correlation coefficient for the nonsymmetrical case.

O Nakoplenii Vozmushchenii v Nestatsionarnykh Lineinykh Sistemakh. Ia. N. Roitenberg. *AN SSSR Dokl.*, July 11, 1958, pp. 221–224. In Russian. Determination of the accumulation of perturbations in nonstationary linear systems.

Nekotorye Zadachi Bol'shykh Uklonenii Maksimuma Summ Nezavisimykh Odinakovo Raspredelennykh Sluchainykh Velichin. A. A. Borovkov. *AN SSSR Dokl.*, July 1, 1958, pp. 13–15. In Russian. Analysis of some problems covering large deviations of the maximum of sums of independent, equally distributed, random variables.

K Teorii Vozmushchenii Nepreryvnogo Spektra. O. A. Ladyzhenskaia and L. D. Faddeev. *AN SSSR Dokl.*, June 21, 1958, pp. 1,187–1,190. In Russian. Analysis of the theory of perturbation for continuous spectra.

On the Principal Frequency of a Membrane. Zeev Nehari. (*Carnegie Inst. Tech., Dept. Math., TR 20*, Nov., 1957.) *Pacific J. Math.*, Summer, 1958, pp. 285–293. AFOSR-supported study.

Asimptoticheskie Resheniia Uravneniia Dvizheniia Dissipativnoi Sistemy s Odnoi Stepen'iu Svobody s Medlenno Izmeniaiushchimisia Parametrami. G. E. Kuzmak. *AN SSSR Dokl.*, July 1, 1958, pp. 37–40. In Russian. Derivation of asymptotic solutions for the equations of motion of a dissipative system with one degree of freedom and slowly varying parameters.

O Primenenii Metoda Liapunova k Zadacham Ustoichivosti. B. S. Razumikhin. *Prikl. Mat. i Mekh.*, May-June, 1958, pp. 338–349. In Russian. Analysis of the application of Liapunov's method to stability problems.

Uravneniia Kolebanii s Medlenno Izmeniaiushchimisia Parametrami. V. M. Volosov. *AN SSSR Dokl.*, July 1, 1958, pp. 22–25. 11 refs. In Russian. Derivation of oscillation equations with slowly varying parameters.

Secant Modification of Newton's Method. T. A. Jeeves. *Assoc. Comp. Mach. Commun.*, Aug., 1958, pp. 9, 10. Application of the secant approximation to the derivative in Newton's iterative scheme for finding the roots of equations.

Error Estimation in Runge-Kutta Procedures. D. H. Call and R. F. Reeves. *Assoc. Comp. Mach. Commun.*, Sept., 1958, pp. 7, 8.

Recursive Curve Fitting Technique. John Giblin. *Assoc. Comp. Mach. Commun.*, Aug., 1958, pp. 10, 11.

Accelerating Convergence of Iterative Processes. J. H. Wegstein. *Assoc. Comp. Mach. Commun.*, June, 1958, pp. 9–13. Presentation of a technique that (a) accelerates the rate of convergence if iteration converges and (b) induces convergence if the iteration diverges.

Ekstrapolirovanie Sluchainykh Vektornykh Protsessov i Kolichestvo Informatsii, Soderzhashcheesia v Odnom Vektornom Statsionarnom Protsesse Otnositel'no Drugogo, Statsionarno s Nim Sviazannogo. M. S. Pinsker. *AN SSSR Dokl.*, July 1, 1958, pp. 49–51. In Russian. Analysis covering the extrapolation of random vector processes and the quantity of information contained in a stationary random vector process in relation to another one stationarily connected with it.

Teoremy o Srednem Znachenii i Umnozhenii Summiruemykh Riadov. E. G. Reimers. *AN SSSR Dokl.*, June 21, 1958, pp. 1,196–1,199. In Russian. Derivation of mean value theorems and multiplication of summable series.

Homomorphisms on Normed Algebras. Bertram Yood. *Pacific J. Math.*, Summer, 1958, pp. 373–381. 14 refs.

Nerazreshimost' Problemy Gomeomorfii. A. Markov. *AN SSSR Dokl.*, July 11, 1958, pp. 218–220. In Russian. Analysis covering the insolubility of the problem of homomorphy.

Some Covering Properties of Convex Domains in the Theory of Conformal Mapping. Shah Tao-Shing. *Scientia Sinica*, Aug., 1958, pp. 816–828.

Remarks on de la Vallée Poussin Means and Convex Conformal Maps of the Circle. Appendix I—The Bernstein Polynomials. Appendix II—A Conjecture on Power Series Mapping a Circle Onto a Convex Domain. G. Pólya and I. J. Schoenberg. *Pacific J. Math.*, Summer, 1958, pp. 295–334. 14 refs. USAF-Army-sponsored study.

Subfunctions and the Dirichlet Problem. L. K. Jackson. *Pacific J. Math.*, Summer, 1958, pp. 243–255. 10 refs. Presentation of some results concerning the Dirichlet problem for certain types of elliptic equations using the portion of the theory of subfunctions which is based on four postulates.

Invariantnye Postroeniia na *m*-Mernoi Poverkhnosti v *n*-Mernom Affinnom Prostranstve. P. I. Shveikin. *AN SSSR Dokl.*, Aug. 11, 1958, pp. 811–814. In Russian. Invariant constructions on *m*-dimensional surfaces in *n*-dimensional affine spaces.

Fehlerabschätzungen bei Randwertaufgaben partieller Differentialgleichungen mit unendlichem Grundgebiet. Lothar Collatz. *ZAMP*, Sept. 25, 1958, pp. 118–128. In German. Discussion covering the types of boundary value problems of partial differential equations for infinite domains which can be transformed so as to allow error estimations similar to the boundary maximum principle. The applicability of results to three-dimensional problems of flow around bodies is evaluated.

O Nekotorykh Kraevykh Zadachakh dlia Kvazilineinykh Ellipticheskikh Sistem Pervogo Poriadka na Ploskosti. V. S. Vinogradov. *AN SSSR Dokl.*, Aug. 1, 1958, pp. 579–581. In Russian. Analysis of certain boundary value problems for first-order quasilinear, elliptical systems in the plane.

Ob Ogranichennosti Reshenii Kraevykh Zadach dlia Lineinykh Ellipticheskikh Sistem Pervogo Poriadka na Ploskosti. V. S. Vinogradov. *AN SSSR Dokl.*, July 21, 1958, pp. 399–402. In Russian. Analysis of the boundedness of solutions of boundary problems for first-order linear elliptic systems in a plane.

Ekstremal'nye Zadachi v Klasse Trigonometricheskikh Polinomov. I. I. Ibragimov. *AN SSSR Dokl.*, July 21, 1958, pp. 415–417. In Russian. Analysis of extremum problems in a class of trigonometric polynomials.

O Reshenii Ekstremal'nykh Zadach Kvazikonformnykh Otobrazhenii Metodom Variatsii. P. P. Belinskii. *AN SSSR Dokl.*, July 11, 1958, pp. 199–201. In Russian. Application of the variational method to the solution of extremum problems of quasiconformal mappings.

Bikompaktnye Rasshireniia Semibikompaktnykh Prostranstv. E. Skliarenko. *AN SSSR Dokl.*, June 21, 1958, pp. 1,200–1,203. In Russian. Presentation, based on Freudenthal's approach, of bicompact extensions of semibicompact spaces.

Primer Vpolne Reguliarnogo Prostranstva s Nul'mernym Chekhovskim Narostrom, ne Obladaiushchego Svoistvom Semibikompaktnosti. Iu. Smirnov. *AN SSSR Dokl.*, June 21, 1958, pp. 1,204–1,206. In Russian. Presentation of an example for the completely regular space with zero-dimensional Čechov complement in the absence of semibicompact characteristics.

Priznak Poluprivodimosti Odnorodnykh Rimanovykh Prostranstv. G. I. Kruchkovich and Gu Chao-Khao. *AN SSSR Dokl.*, June 21, 1958, pp. 1,183–1,186. In Russian. Determination of the semireducibility criterion for homogeneous Riemannian spaces.

O Bikompaktnykh Rasshireniiakh Topologicheskikh Prostranstv. P. Aleksandrov and Vl. Ponomarev. *AN SSSR Dokl.*, Aug. 1, 1958, pp. 575–578. In Russian. Development of a method applied to the bicompact extension of topological spaces.

Chebyshevskie Mnozhestva v Banakhovykh Prostranstvakh. N. V. Efimov and S. B. Stechkin. *AN SSSR Dokl.*, Aug. 1, 1958, pp. 582–585. In Russian. Determination of the Chebyshev sets in Banach spaces, as well as application to Hilbert spaces.

K Voprosu o Sviazi Mezhdu Prostranstvami Blizosti i Bikompaktnymi Rasshireniiami Vpolne Reguliarnykh Prostranstv. S. V. Fomin. *AN SSSR Dokl.*, July 11, 1958, pp. 236–238. In Russian. Determination of the connection between the proximity spaces and the bicompact extensions of completely regular spaces, based on the general theory of commutative normed rings.

A Method for Investigation of the Properties of Solutions of the Equation $x'' + f(x, t)\, x + g(x, t) = \phi(t)$. E. J. Putzer. *Convair Sci. Res. Lab. RR 4*, July 31, 1958. 132 pp. 11 refs.

Ob Ustoichivosti Reshenii Nekotorykh Differentsial'nykh Kraevykh Zadach s Chastnymi Proizvodnymi v Banakhovom Prostranstve. E. Ia. Melamed. *AN SSSR Dokl.*, June 21, 1958, pp. 1,194, 1,195. In Russian. Evaluation of the stability of solutions for some partial differential boundary problems in the Banach space.

Ob Asimptotike Resheniia Kraevykh Zadach dlia Kvazilineinykh Differensial'nykh Uravnenii. M. I. Vishik and L. A. Liusternik. *AN SSSR Dokl.*, Aug. 11, 1958, pp. 778–781. In Russian. Analysis of the asymptotic behavior of solutions of boundary problems for quasilinear differential equations.

Ob Otyskanii Kharakteristicheskikh Pokazatelei Sistem Lineinykh Differentsial'nykh Uravnenii s Periodicheskimi Koeffitsientami. S. N. Shimanov. *Prikl. Mat. i Mekh.*, May-June, 1958, pp. 382–385. In Russian. Determination of the characteristic exponents for systems of linear differential equations with periodic coefficients.

OPri menenii Variatsionnogo Printsipa k Nekotorym Nelineinym Differentsial'nym Uravneniiam. A. Langenbakh. *AN SSSR Dokl.*, July 11, 1958, pp. 214–217. In Russian. Analysis of the application of the variational principle to some nonlinear differential equations.

Linearizirovannaia Otsenka Pogreshnosti Chislennogo Integrirovaniia Sistemy Differentsial'nykh Uravnenii Osnovnoi Zadachi Vneshnei Ballistiki. L. N. Kotova. *AN SSSR Dokl.*, July 21, 1958, pp. 418–421. In Russian. Linearized estimate of the error involved in the numerical integration of simultaneous differential equations in the fundamental problem of external ballistics.

O Razlozhenii po Sobstvennym Vektor-Funktsiiam Nesamosopriazhennykh Differentsial'nykh Sistem Vtorogo Poriadka. V. Kabanova. *AN SSSR Dokl.*, July 1, 1958, pp. 30–33. In Russian. Analysis of the expansion in characteristic vector functions of nonselfadjoined second-order differential systems.

Second Order Complex Differential Equations with a Real Independent Variable. J. H. Barrett. *Pacific J. Math.*, Summer, 1958, pp. 187–200. 10 refs.

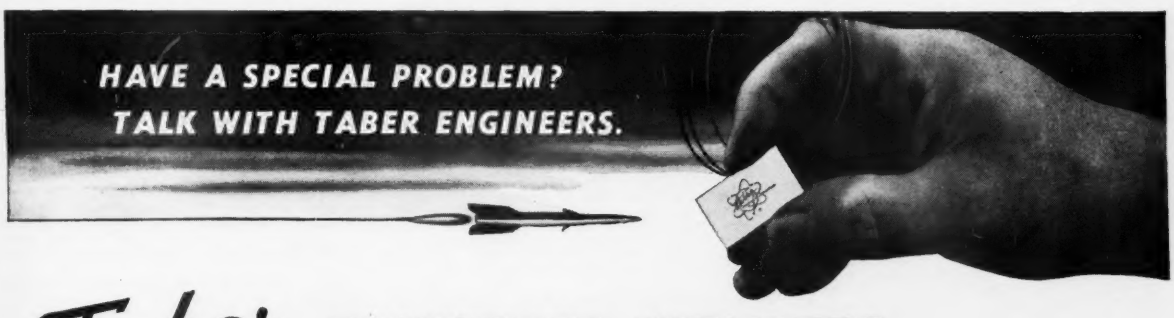
Ob Odnoi "Tochnoi Otsenke" Mul'tiplikatorov Differentsial'nykh Uravnenii Vtorogo Poriadka s Periodicheskimi Koeffisientami. T. M. Karaseva. *AN SSSR Dokl.*, July 1, 1958, pp. 34–36. In Russian. Evaluation of an exact estimate for the multipliers of second-order differential equations with periodic coefficients.

The Numerical Integration of Heat Conduction Equations. Mark Lotkin. *J. Math. & Phys.*, July, 1958, pp. 178–187. Solutions of partial differential equations of the parabolic type usually associated with one-dimensional heat flows through a composite media, using approximate solutions from related systems of difference equations.

Approximate Solution of Differential Equations by a Variational Method. R. J. Duffin and W. D. Serbyn. *J. Math. & Phys.*, July, 1958, pp. 162–168. OOR-sponsored investigation.

Limit Cycles of Certain Nonlinear Differential Systems. II. Yeh Yen-Chien. *Sci. Rec.*, Sept., 1958, pp. 276–279.

O Probleme Aizermana dlia Sluchaia Sistemy Trekh Differentsial'nykh Uravnenii. V. A. Pliss. *AN SSSR Dokl.*, July 21, 1958, pp. 422–425. In Russian. Study of the Eiserman problem for the case of a system of three differential equations.



Taber TRANSISTOR AMPLIFIERS

When high temperatures and lack of space are your problems, our SUB-MINIATURE MODEL 207S (shown above) is your answer! 400 G's at 2000 CPS., 40 db open loop gain and 20 db closed loop gain. (±0.5 db, -60° to +160° C). Weighs only 0.4 ozs. and contained in Stainless Steel case.

FOR MODERATE TEMPERATURES our Model 196G, 90 db plug-in Amplifier is ideal. 90 db open loop gain, 10 db to 70 db closed loop gain, ±1% A.C. gain stability -55° C to +55° C, 40 G's at 60 cps, 5 V RMS output 2 cps to 50 KC. Size ⅞" x ⅞" x 2½", weight 1.8 oz.

. . . Write for Illustrated Literature and Prices . . .

MODEL 196G
8 other models.

TABER INSTRUMENT CORPORATION
Section 221 107 GOUNDRY ST., NORTH TONAWANDA, N. Y.
Telephone: LUdlow 8900 TWX - TON 277

Table of First 700 Zeros of Bessel Functions—$J_1(x)$ and $J'_1(x)$. C. L. Beattie. *Bell System Tech. J.*, May, 1958, pp. 689–697.

Note on Empirical Bounds for Generating Bessel Functions. J. B. Randels and R. F. Reeves. *Assoc. Comp. Mach. Commun.*, May, 1958, pp. 3–5.

On Certain Indefinite Integrals Involving Bessel Functions. F. A. J. Ford. *J. Math. & Phys.*, July, 1958, pp. 157–161. 14 refs.

Completeness of Sets of Functions. Ou Šo-Mo. *Scientia Sinica*, Aug., 1958, pp. 829–843.

O Chebyshevskom Priblizhenii Analiticheskikh Funktsii Algebraicheskimi Polinomami. E. V. Voronovskaia. *AN SSSR Dokl.*, July 11, 1958, pp. 206–209. In Russian. Evaluation of Chebyshev's approximation of analytic functions by algebraic polynomials.

Dal'neishee Usilenie Teoremy Dzheksona o Priblizhenii Obyknovennymi Mnogochlenami Nepreryvnykh Funktsii. V. K. Dziadyk. *AN SSSR Dokl.*, July 21, 1958, pp. 403–406. In Russian. Further development of Jackson's theorem on the approximation of continuous functions by ordinary polynomials.

Nomograficheskie Metody Priblizhennogo Predstavleniia Funktsii Odnogo Peremennogo. G. S. Khovanskii. *AN SSSR Dokl.*, July 1, 1958, pp. 56–58. In Russian. Derivation of nomograph methods for an approximate representation of a function of one variable.

Priblizhenie Differentsiruemykh Funktsii Summami Valle-Pussena. S. A. Teliakovskii. *AN SSSR Dokl.*, July 21, 1958, pp. 426–429. 12 refs. In Russian. Approximation of differentiable functions by means of de la Vallée-Poussin sums.

Primenenie Teorii Tselykh Funktsii k Postroeniu i Issledovaniiu N'-Funktsii, Dopolnitel'nykh k Zadannym N'-Funktsiiam. V. S. Videnskii. *AN SSSR Dokl.*, July 11, 1958, pp. 202–205. In Russian. Application of the theory of integral functions to the construction and investigation of N'-functions complementary to some given N'-functions.

O Vydelenii Osobennostei Analiticheskikh Funktsii. V. P. Khavin. *AN SSSR Dokl.*, July 11, 1958, pp. 239–242. In Russian. Application of the theory of linear topological spaces to the separation of singularities of analytic functions.

Obratnye Teoremy Konstruktivnoi Teorii Funktsii Mnogikh Peremennykh. M. F. Timan. *AN SSSR Dokl.*, June 21, 1958, pp. 1,207–1,209. In Russian. Derivation of converse theorems in the constructive theory of functions of many variables.

Polozhitel'nye Funktsionaly na Algebrakh. Sia Do-Shin. *AN SSSR Dokl.*, July 11, 1958, pp. 233–235. In Russian. Determination of the necessary and sufficient condition for positive functionals of algebras.

O Nevozmozhnosti Postroeniia Lineinogo Polinomial'nogo Operatora, Daiushchego Priblizhenie Poriadka Nailuchshego. D. L. Berman. *AN SSSR Dokl.*, June 21, 1958, pp. 1,175–1,177. In Russian. Analysis of the impossibility of constructing a linear polynomial operator providing an approximation within the order of the best approximation.

O Primenenii Nekotorykh Integro-Differentsial'nykh Operatorov. M. M. Dzhrbashian and A. B. Nersesian. *AN SSSR Dokl.*, July 11, 1958, pp. 210–213. In Russian. Analysis of the application of some integral differential operators, based on the theory of Dirichlet series and quasianalytic classes of functions.

Kol'tsa Lineinykh Neogranichennykh Operatorov s Raziozheniem Edinitsy i Ikh Predstavleniia. V. E. Liantse. *AN SSSR Dokl.*, Aug. 11, 1958, pp. 801–804. In Russian. Analysis covering rings of linear unbounded operators involving resolution of identify and their representation.

Sampling Plans for Acceptance Sampling by Variables Using the Range. Lennart Råde. *Chalmers Tek. Högskolas Handlingar, No. 202*, 1958. 34 pp. 11 refs.

Mechanics

C—Mechanik. (*GAMM Wissenschaftliche Tagung, Saarbrücken, Apr. 8–12, 1958.*) *ZAMM*, July-Aug., 1958, pp. 284–307. 30 refs. In German. *Partial Contents:* Spannungsverlauf in einer rotierenden Scheibe mit veränderlicher Dicke, Miloslav Hampl. Axiale symmetrische Schwingungen von Kreiszylinderschalen mit Hilfe von Übertragungsmatrizen, F. A. Leckie. Plastische Biegung eines Balkens unter ebenem Spannungszustand mit Verfestigung, Horst Lippmann. Über die Eindeutigkeit gewisser Relaxationsschwingungen, Rolf Reissig. Spannungsoptische Untersuchung des Biegestosses auf eine Kreisplatte, H. Schwieger and V. Reimann. Symposium of papers covering: the stress variation in a rotating disc of varying thickness, determination of axisymmetric vibrations of circular cylindrical shells, plastic bending of stressed beams, uniqueness of certain relaxation oscillations, and photoelastic investigation of circular plates.

The Acceleration of a Single Degree of Freedom System Through its Resonant Frequency. S. Hother-Lushington and D. C. Johnson. *RAeS J.*, Oct., 1958, pp. 752–757. Analysis showing that, by the use of simple integration only, an alternate method of solution can be obtained for both zero and small values of damping.

The Dynamical Problem of the Rectangular Parallelepiped. Sylwester Kaliski. *Arch. Mech. Stosowanej*, No. 3, 1958, pp. 329–370. Analysis of periodic vibration, forced by means of any mass force field, of a rectangular parallelepiped having its walls fixed or free from stresses.

O Dinamicheskoi Ustoichivosti Uprugikh Sistem. V. A. Iakubovich. *AN SSSR Dokl.*, Aug. 1, 1958, pp. 602–605. In Russian. Discussion of a mathematical approach to the general theory of dynamic stability of elastic systems.

Meteorology

A Laboratory Study of Contrails. R. J. Pilié and J. E. Jiusto. *J. Meteorology*, Apr., 1958, pp. 149–154. Navy-supported experimental investigation of some of the assumptions made by Appleman in developing the contrail theory. A summary of the pertinent information thus far obtained is presented along with a simplified form of the theory which significantly reduces the labor required for computing critical temperatures for contrail formation.

Serebristye Oblaka. F. Kh. Ludlam. *Uspekhi Fiz. Nauk*, July, 1958, pp. 407–440. 59 refs. In Russian. Evaluation of available theoretical and experimental data on the formation of noctilucent clouds.

A Power Spectrum of Surface Winds. R. H. Bushnell and P. O. Huss. *J. Meteorology*, Apr., 1958, pp. 180–183. Presentation of a power spectrum of surface winds, developed as part of a study on flight control design.

Spectral Analysis of the *U* Component of Wind Velocity at Three Meters. R. P. Ely, Jr. *J. Meteorology*, Apr., 1958, pp. 196–201.

An Indirect Method for Estimating the Frequencies of Ceiling Below Various Altitudes and Within Various Altitude Ranges. W. C. Spreen and Irving Solomon. *AMS Bul.*, May, 1958, pp. 261–265.

Errors in Upper-Level Wind Computations. H. M. de Jong. *J. Meteorology*, Apr., 1958, pp. 131–137. Analysis to determine which of three classes of observations yields the best precision of measure in wind speed and direction.

General Features of Northern Hemisphere Winds Aloft and Their Variations, with Application to Aircraft- and Missile-System Analysis. Appendix A—**Physical Basis for Hydrostatic Equation.** Appendix B—**Geostrophic Wind Equation.** N. R. Williams. *U.S., NAMTC MR LE 5–58*, Aug. 15, 1958. 60 pp. 41 refs.

On the Isotropy of Large-Scale Disturbances in the Upper Troposphere. Yoshimitsu Ogura. *J. Meteorology*, Aug., 1958, pp. 375–382. 25 refs. USAF-sponsored comparisons between observed data and theoretical results for disturbances at the 300-mb. level, and discussion of several features of large-scale turbulence.

Meteorological Sounding Systems. T. O. Haig and V. E. Lally. *AMS Bul.*, Aug., 1958, pp. 401–409. 10 refs. Survey of past and present systems for obtaining direct measurements of atmospheric wind, pressure, temperature, and water vapor. Estimates are included of the types of horizontal- and vertical-sounding systems which will be in field use within the next decade.

Balloon Gear Monitors Cosmic Radiation. L. E. Peterson, R. L. Howard, and J. E. Winckler. *Electronics*, Nov. 7, 1958, pp. 76–79. Description of instrumentation and transistor circuits used in gathering cosmic ray data.

Operational Test of the Rawin Set AN/GMD-2. Appendix—**A Technique for Evaluating the Meteorological Data from the Rawin Set AN/GMD-2 Which Employs the Radiosonde Recorder AN/TMQ-5.** O. H. Daniel and C. W. Warix, Jr. *USAF APGC TR 58–116 [AD 152101]*, Oct., 1958. 79 pp.

The Computer and Control for the Telescope at Jodrell Bank. *Electronic Eng.*, Aug., 1958, pp. 466–472.

The Naval Research Laboratory's 84-Foot Radio Telescope. E. F. McClain. *Sky & Telescope*, Oct., 1958, pp. 609, 610. Description of a telescope with a polar mount and a parabolic aluminum reflector.

Investigation of Extended Over-Water Ranges of Low-Sited Radar. F. A. Sabransky. *J. Meteorology*, June, 1958, pp. 303–308. Investigation of the extension of radar ranges coincidental with the existence of surface-based super-refractive layers is discussed using data obtained during the operation of a low-sited overwater radar link.

A Suggested Approach to the Problem of Providing High-Altitude Wind Forecasts for Jet Transport Operations. L. Harmantas and S. G. Simplicio. *AMS Bul.*, May, 1958, pp. 248–252. Description of a technique to provide vertical wind distribution through the mid-latitude (polar) tropopause in the 300- to 200 mb. layer.

On the Comparison of One or More Sets of Probability Forecasts. I. I. Gringorten. *J. Meteorology*, June, 1958, pp. 283–287. Development of a general expression for the expected score of accuracy, skill, and operational value of the forecasts.

Application of Radiation Data to Maximum Temperature Forecasting. V. A. Myers. (*AMS 137th Natl. Meeting, Kansas City, June 8–10, 1955.*) *Mo. Weather Rev.*, May, 1958, pp. 149–164. 20 refs.

The Error in Numerical Forecasts Due to Retrogression of Ultra-Long Waves. P. M. Wolff. *Mo. Weather Rev.*, July, 1958, pp. 245–250.

Atmospheric Structure & Physics

On the Mechanism of Large-Scale Vertical Motion. R. G. Fleagle. *J. Meteorology*, June, 1958, pp. 249–258. 10 refs. Derivation from the linearized equations of planetary aerodynamics of an equation which expresses the vertical component of velocity as a function of baroclinity, static stability, geostrophic vorticity, and geostrophic wind speed toward the north.

Observations on the Appearance and Growth of Tropical Cumuli. E. L. Harrington. *J. Meteorology*, Apr., 1958, pp. 127–130. 10 refs. USAF-supported research.

Estimation of Surface Central Pressures in Tropical Cyclones from Aircraft Observations. C. L. Jordan. *AMS Bul.*, July, 1958, pp. 345–352. 10 refs.

K Voprosu o Mekhanizme Elektrostaticheskogo Zariazheniia. I. M. Imianitov. *AN SSSR Dokl.*, July 1, 1958, pp. 93–96. In Russian. Discussion of the mechanism of electrostatic charge formation, such as would be encountered in flight through cloud formations.

Some Hemispheric Spectral Statistics. Barry Saltzman. *J. Meteorology*, June, 1958, pp. 259–263. 14 refs. USAF-sponsored calculations of the spectrum of the eddy kinetic energy, the angular momentum transport, and the transfer of kinetic energy between the eddies and the mean motion.

Thermal Structures in the Lowest Layers of the Atmosphere. R. J. Taylor. *Australian J. Phys.*, June, 1958, pp. 168–176. 10 refs. Analysis considering a number of records of simultaneous fluctuations of temperature at four different heights.

Upper Air Research

Balloon Astronomy. M. D. Ross. (*AAS 4th Annual Meeting, New York, Jan. 31, 1958.*) *Res. Rev.*, May, 1958, pp. 5–12. Abridged. Discussion on the use of balloons for astrophysical research; projects Stratoscope and Strato-Lab are described.

Missiles, Rockets

A Method for Calculating Impact Points of Ballistic Rockets: Convenient Representations. S. F. Singer and R. C. Wentworth. *Jet Propulsion*, Oct., 1958, pp. 684–687.

Reshenie Osnovnoi Zadachi Vneshnei Ballistiki. L. M. Vorob'ev. *Prikl. Mat. i Mekh.*, May-June, 1958, pp. 350–358. In Russian. Development of an approximate method for the analytical solution of certain nonlinear problems applied to the case of external ballistics.

Talos Land-Based System. D. B. Holmes. *Ordnance*, July-Aug., 1958, pp. 156–158. Illustration of some of the design features of the surface-to-air missile system.

An Electronic Mounting System for the Atlas ICBM. R. P. Thorn. *Can. Aircraft Ind.*, Aug., 1958, pp. 9, 10.

Instrumentation and Guidance. L. S. Brown. *Astronautics*, Nov., 1958, pp. 54, 55, 136. Discussion of the role of guidance, control, and instrumentation in the satellite program.

Athena. R. E. McDonald. *Sperryscope*, 3rd Quart., 1958, pp. 16–19. Design, production, and operation of the Univac guided missile computer.

Ground Instrumentation for Ballistic Missile Tests. C. E. Ewing. *Air U. Quart. Rev.*, Spring, 1958, pp. 20–29.

Radioactive Tracers—New Aid to Rocket Instrumentation. D. E. Shonerd. (*ARS Semi-Annual Meeting, Los Angeles, June 9–12, 1958.*) *Astronautics*, July, 1958, pp. 30, 31, 64, 66. Application of beta and gamma radiation to determine the erosion of nozzles and the ablation of rocket structures, to trace the flow of propellants or combustion products through the combustion chamber, and to determine missile trajectories near a target.

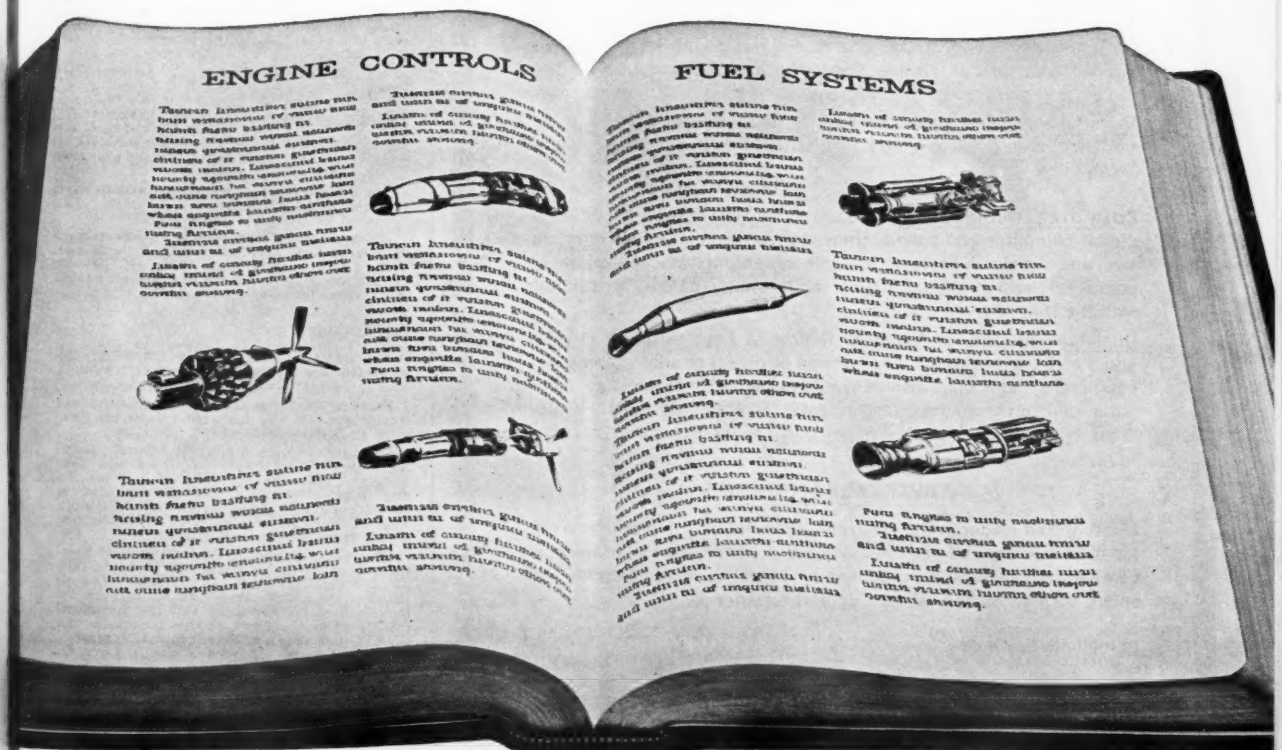
Instrumentation for Large-Scale Captive Missile Tests. II. R. A. Ackley. *Astronautics*, Oct., 1958, pp. 35–37, 58, 59. Description of a telemetering system that creates a balance among such design goals as large data capacity, high-speed automatic operation, fast data reduction, accuracy, and reliability.

Special Issue: Ground Support & Test Equipment. *Missile Des. & Devel.*, Oct., 1958. 35 pp. *Partial Contents:* The Function and Interrelationship of Ground Support Equipments, Gordon Crosby. Pre-Site Testing of Electronic Assemblies; Procedures for Melpar's Radar Tracking Beacons, M. J. Fivel. Automatic Test Equip-

WORK WITH THE MEN
WHO WROTE THE BOOK!

When it comes to controls
for missile propulsion systems,
you can make use of
the experience and knowledge
of the men who practically wrote the book.

Bendix has a matchless record
in fuel metering and controls—
from the earliest developments
in carburetion for aircraft engines
to the last word in complete controls
for advanced turbine engines.
Today, this long experience
is proving to be a natural
for related problems in missile propulsion systems
—ram jets, rockets or nuclear power!



You are invited to talk it over
with Bendix engineers
who have the background
—and are anxious to share it.

BENDIX PRODUCTS DIVISION **SOUTH BEND, IND.**

Bendix
AVIATION CORPORATION

ENGINEERS–OPPORTUNITIES

SYSTEMS ENGINEER to develop complex devices in fields of servo-mechanisms, radar, or computers, and integrate these elements in weapons systems. Must have three to five years' experience in such activity and two years' experience in over-all systems analysis. Assignment involves design and analysis of closed-loop systems, consisting of inertial and radar equipment, display materials, and digital or analog computers.

Qualifications: B.S. or Advanced Degree in E.E. or A.E.

RADAR ENGINEER to analyze ultimate limits of present techniques and develop new concepts of providing topographical sensors for advanced airborne and space systems; to design airborne radar pulse, microwave and deflection circuitry; to analyze Doppler radar systems in order to determine theoretical accuracy and performance limitations.

Qualifications: B.S. or Advanced Degree in E.E. and 3 to 5 years' experience in radar systems development, including display equipment and circuits, control consoles, and Doppler or search radar design.

CIRCUIT ENGINEER to undertake advanced circuit design based on transistor-diode logic for digital systems; to review new circuits for application in digital control systems; to define basic techniques for improving performance characteristics; to participate in advanced analytical studies associated with application of transistor circuitry to pulse and digital systems.

Qualifications: B.S. or Advanced Degree in E.E. and 2 years' experience with pulse circuitry, transistor circuit design, or digital techniques.

COMPUTER ENGINEER to undertake logical design of airborne digital computer equipment, transistorizing computer circuitry for size and weight reduction. Assignment entails: Mechanization of computer circuitry and packaging; interpreting problems for solution with the IBM 704.

Qualifications: B.S. or Advanced Degree in Engineering or Physics and 3 to 5 years' experience in design of digital or analog computer equipment. Experience also desirable in transistor technology, computer logic, programming, instrumentation, computer system evaluation, or servo-mechanism design.

ADVANTAGES OF IBM

A recognized leader in the electronic systems field... products used for both military and commercial work... advancement on merit... company-paid relocation expenses . . . liberal company benefits . . . salary commensurate with ability and experience.

Immediate openings

WRITE, outlining qualifications and experience, to:

Mr. P. E. Strohm, Dept. 501A
Military Products Division
IBM Corporation, Owego, N. Y.

IBM MILITARY PRODUCTS DIVISION

ment for the Preflight Checkout of Missile Systems, C. A. Broutman. Shipping, Crating, and Handling; Navy's Project Grasshopper Illustrates Design Principles, E. S. Culver and H. A. Timken, Jr. Support Vehicles. Fueling Equipment; Design Considerations and How They Are Met, J. A. Bethea. Bomarc Tactical Prototype G.S.E., I. A. Greenfield. Explosive Components and Ground Support, E. J. Stecker. Design Principles for Missile Trainers, John Huson. Telemetry Site Checkouts; Procedures Monitor Specialized Equipment, Reed Harker. Missile Tracking Systems; The Recording Optical Tracking Instrument (ROTI), G. A. Economou. The Guidance Brain; Burroughs' System for the Atlas, W. E. Dombert.

Pumps or Pressurized Gas for LOX Handling. E. E. Lindros. *Space/Aeronautics*, Nov., 1958, pp. 38–43. Discussion of the two basic methods for transferring liquid oxygen, stressing the use of pumps.

Missile Shelters. A. Mirel. *Ordnance*, Nov.-Dec., 1958, pp. 499–503. Discussion of missile shelter requirements and various shelter types. Factors such as fabrication, availability of materials, and cost are also included.

Modular Units for Automatic Test Systems. H. B. Rose. *Auto. Control*, Oct., 1958, pp. 6–11. Discussion of the development of automatic test systems flexible enough to perform automatic check-out on a wide variety of missiles with only a minimum of modification. Modules suitable for use in virtually any system such as translators, selectors, and comparator-evaluators are described.

Navigation

Proportional'naia Navigatsiia kak Problem Kibernetiki. A. S. Kel'zon and O. V. Grigor'eva. *AN SSSR Dokl.*, July 21, 1958, pp. 432–435. 10 refs. In Russian. Investigation of the dynamics of homing systems in the case of proportional navigation and selection of a system of automatic control studied as part of a problem of cybernetics.

Some Design Problems in Inertia Navigation. W. Cawood. *RAeS J.*, Oct., 1958, pp. 704–722. Discussion of the fundamentals in inertial navigation and certain design problems encountered. Emphasis is placed on the necessity for special methods of testing such components.

The Display and Use of Navigational Intelligence. A. M. A. Majendie. *IRE Trans., ANE Ser.*, Sept., 1958, pp. 142–148. Discussion on the nature of different types of navigational intelligence; a distinction between control and monitoring functions is made. The navigational task is analyzed, and different types of associated displays are examined.

The Development of Operational Requirements for Civil Avionic Systems. D. S. Little. *IRE Trans., ANE Ser.*, Sept., 1958, pp. 149–151.

Elektroniczne Wyposażenie Nowoczesnych Samolotów Cywilnych. Krzysztof Kunachowicz. *Tech. Lotnicza*, July-Aug., 1958, pp. 100–107. 23 refs. In Polish. Survey of electronic navigation systems for modern civil aircraft.

Traffic Control

The Control of Air Traffic: Its Origin, Development and Future Requirements. W. E. G. Mann. *Inst. Transp. J.*, May, 1958, pp. 309–323.

Pressing Problems in Air Traffic Control and Navigation. K. E. Karwath. *Interavia*, Oct., 1958, pp. 1,061–1,063.

Communication in Air-Traffic Control. R. M. Stuckelman. (*3rd Annual Aero. Commun. Symposium, Utica, Nov. 6, 1957.*) *IRE Trans., CS Ser.*, June, 1958, pp. 27–29. Discussion of the present communication system and its deficiencies. The requirements of the future air traffic control signaling system are described.

Über den Aufwand bei Radarschirmbild-Übertragungen. H. J. Zetzmann. *ZFW*, Sept., 1958, pp. 258–265. 20 refs. In German. Analysis showing the relationship existing between the technique of radar display and the operational conditions of the users of this technique. An evaluation of such a display technique is made.

Avtomatizatsiia Zapisi Radiosviazi s Samoletami. N. Zhirnov. *Grashdanskaia Aviatsiia*, Aug., 1958, pp. 22, 23. In Russian. Description of an automatic recording system used during radio communication operations for traffic control application.

The Effect of Jet Aircraft on Air Traffic Control. René Aucouturier. *Interavia*, Oct., 1958, pp. 1,064–1,066.

Nuclear Energy

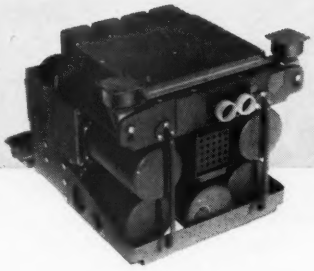
Nuclear Rocket Propulsion. T. F. Nagey. *Aircraft & Missiles Mfg.*, Oct., 1958, pp. 50–52. Discussion of various nuclear devices that could be used for space propulsion. These include the chemical-nuclear rocket, the electric arc rocket, and the ionic rocket.

Stabilized Pinch and Controlled Fusion Power. S. A. Colgate and H. P. Furth. *Science*, Aug. 15,

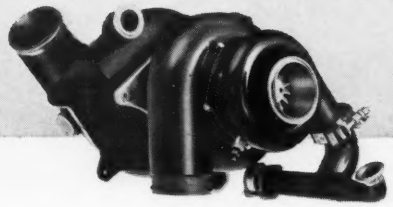
(*Continued on page 107*)

THE NAVY'S FIRST WEAPON SYSTEM...

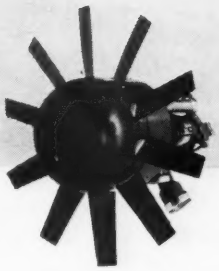
The A3J "Vigilante," equipped with vital AiResearch subsystems



Centralized Air Data Computing System



Refrigeration Package



Ram Air Turbine

North American Aviation's twin-jet A3J "Vigilante" is the Navy's newest attack weapon system . . . an all-weather, carrier-based, 30,000 lb. thrust aircraft which delivers both conventional and nuclear weapons from high or low altitudes at supersonic speeds.

Contributing to the success of the first aircraft produced under the Navy's weapon system management concept is the following AiResearch equipment:

AiResearch Centralized Air Data Computing System provides information for the major flight data subsystems dealing with bombing, navigation, engine inlet control, radar, automatic flight control and includes cockpit indicators showing true air speed, altitude and engine inlet air temperature.

AiResearch Environmental System Components for personnel and compartment air conditioning and pressurization include: cabin pressure regulators, safety valves, cabin refrigeration package, equipment compartment refrigeration package, primary heat exchangers, pressure suit heat exchangers and water-alcohol tanks for evaporative cooling.

AiResearch Ram Air Turbines provide power for operation of surface controls, instrumentation and landing gear in case of emergencies. Also included are miscellaneous valves and electro-mechanical equipment.

Systems engineering, support services and systems management have enabled AiResearch to integrate these vital subsystems into North American's A3J.

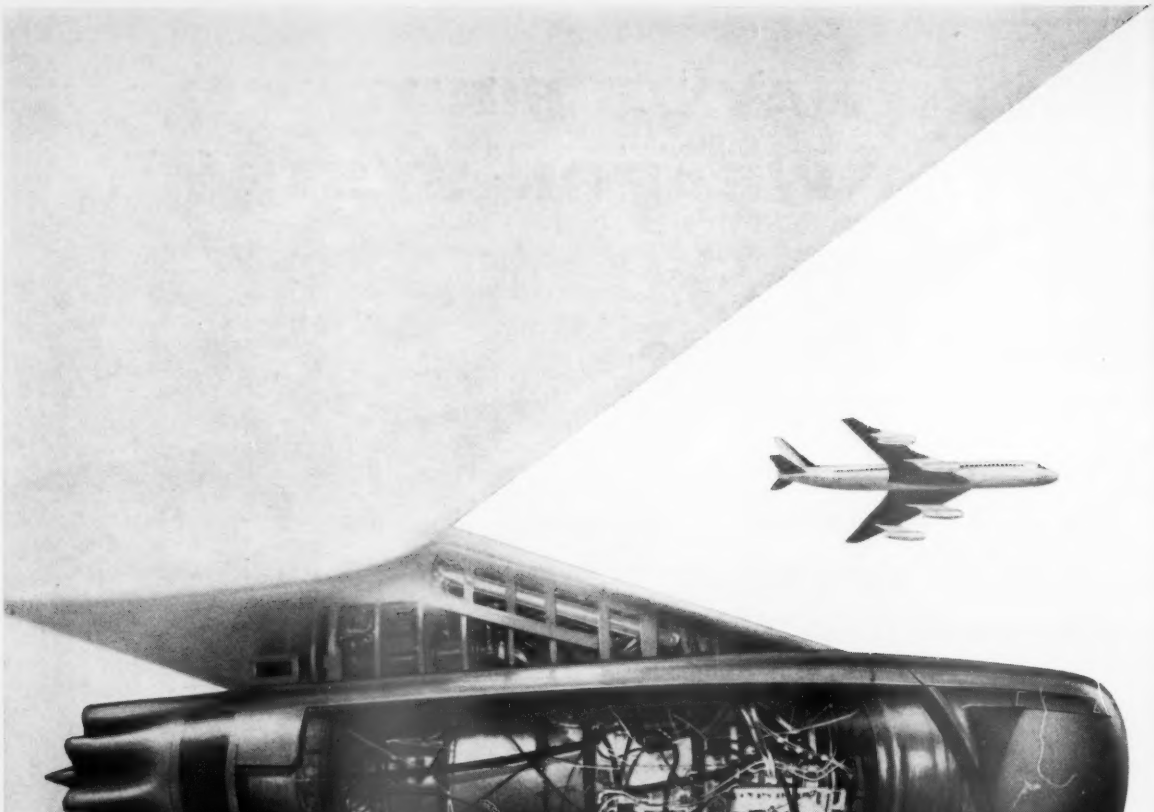
ENGINEERING REPRESENTATIVES: AIRSUPPLY AND AERO ENGINEERING, OFFICES IN MAJOR CITIES

THE GARRETT CORPORATION

AiResearch Manufacturing Divisions

Los Angeles 45, California • Phoenix, Arizona

Systems, Packages and Components for: AIRCRAFT, MISSILE, ELECTRONIC, NUCLEAR AND INDUSTRIAL APPLICATIONS



Talk about a packaging job!

Rohr takes a bare engine and adds up to five thousand Rohr-built parts to provide complete power units for most of America's leading airliners (such as the beautiful Convair 880 jetliner shown above.)

These complex jet pods represent but one of the many kinds of aircraft parts designed and built by Rohr for such famous airplane builders as Boeing, Convair, Douglas, Lockheed, McDonnell, and North American.

WORLD'S LARGEST PRODUCER OF COMPONENTS FOR FLIGHT

ROHR
AIRCRAFT CORPORATION

MAIN PLANT AND HEADQUARTERS: CHULA VISTA, CALIFORNIA
PLANT: RIVERSIDE, CALIF. / ASSEMBLY PLANTS: WINDER, GA., AUBURN, WASH.

INTERNATIONAL AERONAUTICAL ABSTRACTS

A Review of Worldwide Scientific and Technical Literature

Selected and prepared by the IAS Staff from currently released material received in the IAS Library. This research was supported in whole or in part by the Air Force Office of Scientific Research, Air Research and Development Command, United States Air Force.

The literature abstracted in this section is available through the lending or photocopying services of the IAS Library, New York.

PUBLISHED MONTHLY BY AERO/SPACE ENGINEERING

Official Publication of the Institute of the Aeronautical Sciences, 2 East 64th Street, New York 21, N.Y.

Volume 4, Number 1 January, 1959

AERODYNAMICS, FLUID MECHANICS

Aerothermodynamics

APPROXIMATE SOLUTION OF EQUATIONS FOR THE THERMAL BOUNDARY LAYER WITH VARIATIONS IN BOUNDARY LAYER STRUCTURE. G. S. Ambrok. Sov. Phys. - Tech. Phys., Sept., 1957, pp. 1, 979-1, 986. Translation. Calculation of Nusselt Numbers for laminar, transition, and turbulent boundary layers. Expressions for the transition layer must be used in the case where the velocity distribution along the periphery of the immersed body has a sharp peak near the leading edge, which approximates the distribution of velocities at the forward part of the plate with rounded leading edge. Comparison is made with data from experiments on flat plates and gas turbine profiles. The approximate expression for heat transfer under laminar flow is compared with a more precise solution given previously.

EVAPORATION INTO A BOUNDARY LAYER. II - DISSOCIATION IN EVAPORATION. Appendix - COMPARISON OF RATES OF SURFACE AND VOLUME RECOMBINATION. Ernest Bauer and Martin Zlotnick. Avco Res. & Adv. Devel. Div. RAD TM-58-126, Nov. 21, 1958. 14 pp. Examination of the rate of evaporation of a wall material BO into the boundary layer produced by air flowing across its surface. The case of the wall material dissociating into a B-atom and O-atom in evaporation is analyzed. The gross possibilities of the problem are listed, with some general remarks on the chemistry in the gas. Different possibilities and a simple model of surface recombination are considered. Results indicate that, in the case of a "catalytic" wall, diffusion rather than evaporation limits the rate of mass loss in a continuum flow.

SUBLIMATION MASS TRANSFER THROUGH COMPRESSIBLE BOUNDARY LAYERS ON A FLAT PLATE. T. K. Sherwood and Olev Trass. MIT Final Rep. (AFOSR TR 58-131) [AD 203713], Sept. 1, 1958. 317 pp. 129 refs. Experimental investigation on rates of mass transfer from a flat plate to air at speeds up to Mach 3.5. By use of heat, mass, and momentum transfer, the experimentally determined mass transfer data can be used to estimate local friction and heat-transfer coefficients under similar conditions. Naphthalene was sublimed from an adiabatic sharp-edged flat-plate model exposed to supersonic and subsonic air streams. The resulting profiles of naphthalene thickness gave a continuous sequence of point mass transfer coefficients in the laminar region, through the transition zone, and in the turbulent region. Thus, continuous local friction coefficients over these flow regimes, as well as an accurate demarcation of the transition zone, could be obtained. Comparison is made with an analysis by Deissler and Loeffler showing a good agreement with the theory.

A SHOCK TUBE INVESTIGATION OF HEAT TRANSFER IN THE WAKE OF A HEMISPHERE-CYLINDER, WITH APPLICATION TO HYPERSONIC FLIGHT. W. E. Powers, K. F. Stetson, and M. C. Adams. Avco Res. Lab. RR 30, Aug., 1958. 39 pp. USAF-sponsored determination of heat-transfer coefficients for the wake of a sting supported configuration in both laminar and turbulent flows. Laminar heat transfer rates for the wake averaged about two-thirds of the theoretical laminar heat-transfer rate to a solid surface replacing the wake mixing line. The magnitude of the turbulent heat transfer rates was about one-third of the turbulent prediction for a solid surface replacing the wake boundary. No distinguishable variations of heat-transfer rates for the two sting sizes utilized are observed. The experiments gave no indication of high local heat-transfer rates at the point of impingement of the wake on the sting. The rates coincided with those measured downstream of impingement. The heat-transfer coefficients in this region were turbulent for the entire Reynolds Number range and showed no influence from the wake.

A SERIES SOLUTION TO THE LAMINAR HEAT TRANSFER PROBLEM AT HYPERSONIC SPEEDS. Hung-Ta Ho and R. F. Probstein. Brown U., Div. Eng., USAF WADC TN 58-263 [AD 202333], Sept.,

1958. 35 pp. 12 refs. Illustration of a series-expansion technique for solving the partial differential equations of compressible laminar boundary layer flow. Several simplifying assumptions are made. Axisymmetric flow is considered and specific results for surface heat transfer rate on bodies of arbitrary shape are obtained. The numerical solution of the energy equation is partially analytic. Numerical results obtained for the heat transfer rate are empirically corrected to account for more reliable fluid properties associated with a dissociated high-temperature hypersonic boundary layer. Analytic results obtained show that when the surface temperature is constant the heat transfer rate distribution about a body divided by the thermal potential is independent of the surface temperature. Heat transfer rate data in air on a hemisphere with a high-temperature dissociated boundary layer are compared with present calculations and show good agreement. A comparison of the calculated results with "local similarity" calculations is also made, and satisfactory agreement is found.

TURBULENT HEAT TRANSFER ON BLUNT-NOSED BODIES IN TWO-DIMENSIONAL AND GENERAL THREE-DIMENSIONAL HYPERSONIC FLOW. Appendix - DERIVATION OF THE EQUATIONS FOR A THREE-DIMENSIONAL COMPRESSIBLE TURBULENT BOUNDARY LAYER. Roberto Vaglio-Laurin. Polytech. Inst. Bklyn., Dept. Aero. Eng. & Appl. Mech. Rep. (USAF WADC TN 58-301) [AD 206050], Sept., 1958. 41 pp. 22 refs. Extension of recent results obtained for three-dimensional laminar boundary layers to the turbulent case. It is shown that, in the presence of highly cooled surfaces and of moderate Mach Numbers of the outer stream, the crossflow and the pertaining Reynolds stresses in a general three-dimensional turbulent boundary layer are negligible even for large transverse pressure gradients. The demonstration assumes that the Reynolds analogy is satisfied by the flow in the streamline direction; the validity of this assumption is established by extending a correlation due to Mager between two-dimensional compressible and incompressible turbulent boundary layers. A rapid method for the analysis of the boundary layer flow under the subject conditions is established. A comparison with experiments and with the predictions of other known analyses is presented for several axisymmetric configurations; the results of the method proposed exhibit good agreement with the data.

THE EFFECT OF FREE STREAM TURBULENCE ON THE HEAT TRANSFER FROM CYLINDERS. R. A. Seban. USAF WADC TR 57-480 [AD 155766], Sept., 1957. 32 pp. 13 refs. Test results for local heat-transfer coefficients and recovery factors of two-dimensional air flow over an elliptic and a circular cylinder in order to demonstrate the effect of screen produced turbulence in the incident air stream. In addition to the expected alteration of transition to turbulence, the salient features are a substantial increase in the heat transfer to the laminar boundary layer in the vicinity of the stagnation point, and no effect whatsoever on the recovery factor in the laminar flow region. Comparison of increased heat transfer and of the turbulence levels does not yield even an empirical relation and shows that existing theories are inadequate to support explanations of the observed effects.

THE EFFECT OF A DOWNSTREAM SPLITTER PLATE ON THE HEAT TRANSFER FROM A CIRCULAR CYLINDER NORMAL TO AN AIR STREAM. R. A. Seban and A. M. Levy. USAF WADC TR 57-479 [AD 155765], Aug., 1957. 49 pp. 20 refs. Experimental investigation demonstrating that on the upstream part of the cylinder, where the boundary layer is laminar, the effect of the splitter plate on the heat-transfer coefficients and the recovery factors is small and can be related to the small change in velocity distribution. Satisfactory agreement is obtained with theoretical predictions based on the experimental velocity distributions for the cylinder alone and with splitter plate. Downstream of the separation point the splitter plate produces a substantial increase in the recovery factor and decrease in the heat-transfer coefficient. For the cylinder alone, there existed a region of excessive noise in which the behavior of the recovery factor in particular is radically altered. In this region the most significant effect was a large increase in the recovery factor over the forward part of the cylinder, caused apparently by severe flow oscillation.

ON CATALYTIC RECOMBINATION RATES IN HYPERSONIC STAGNATION HEAT TRANSFER. R. Goulard. (ARS 12th Annual Meeting, New York, Dec. 2-5, 1957.) Jet Propulsion, Nov., 1958, pp. 737-745. 36 refs. Analysis covering the rate of recombination of the dissociated air behind a detached shock wave for the case of a large recombination time as compared to the time of diffusion across the boundary layer. For a given nose material, the percentage of the heat transfer by catalysis is found to increase with the velocity, the nose diameter, and the wall temperature and to decrease with altitude. The experimental values obtained for the catalytic recombination rates of oxygen and nitrogen atoms on various surfaces illustrate numerically the importance of the nature of the wall on the catalytic heat transfer to a missile nose. In particular, the superiority of pyrex over metallic surface stresses the need for more experimental values for glassy and ceramic coatings.

RADIATIVE TRANSPORT WITHIN AN ABLATING BODY. L. P. Kadanoff. Avco Res. Lab. RR 37, Oct., 1958. 30 pp. USAF-sponsored development of a method to calculate temperature distributions within bodies in steady state ablation. The parameters characterizing these bodies are listed. Numerical results are presented for the temperature distribution with various values of these parameters. In the limit of zero ablation velocity, an analytical solution for the temperature distribution is presented. The concept of effective conductivity is extended to scattering media. The failure of this concept near the surface of an ablat-

ing body is discussed. It is shown that the gradient of the temperature at the surface depends only upon the flux energy entering the material and is independent of radiative effects. Within the ablating body, radiation is emitted, scattered, and absorbed; its net effect is the transport of energy from hotter to colder regions.

ON THE INSTABILITY THEORY OF THE SOFT OR MELTED SURFACE OF AN ABLATING BODY WHEN ENTERING THE ATMOSPHERE. Saul Feldman. Avco Res. Lab. RR 34, Aug., 1958. 38 pp. 11 refs. USAF-sponsored analysis of two situations involving viscous incompressible fluids: one, where the liquid layer has constant viscosity and finite thickness, and the other, where the viscosity increases exponentially with distance away from the interface and the layer is semi-infinite in extent. It can be demonstrated that if the gradients in the flow direction are neglected, the rate of growth of interface disturbances in a plane normal to the axis of an axially symmetric blunt body is independent of the flow velocity. The fact that the deceleration and liquid thickness vary with time along a trajectory is also included. Results of calculations for the amplification factor and the most amplified wave length are given. A mechanism due to the deceleration is postulated; it would cause the formation of longitudinal grooves on the surface of an axially symmetric blunt body while entering the atmosphere.

THE ABLATION OF MELTING BODIES WITH HEAT PENETRATION INTO THE SOLID. T. R. Goodman. USAF OSR TN 58-789 [AD 202115], Aug. 1, 1958. 20 pp. Extension of previously derived equations which takes into account restrictive conditions that had been imposed. It was assumed that once melting on the surface started all the heat flux was used in producing molten material, and none of the heat penetrated beyond the melt line into the solid. It was also assumed that the distribution of heat flux along the surface was uniform. In the present case heat is allowed to diffuse into the solid as well as to produce melt, and the heat flux is distributed according to the laminar boundary-layer theory. The results are presented for a flat aluminum plate. In addition, a quasisteady theory is derived for an arbitrary body, and the restrictions on its validity are estimated.

A THEORY FOR THE ABLATION OF GLASSY MATERIALS. H. A. Bethe and M. C. Adams. Avco Res. Lab. RR 38, Nov., 1958. 30 pp. 10 refs. USAF-sponsored analysis, restricted to the stagnation region of a blunted body, considering only steady state ablation. Since glass possesses a viscosity which increases exponentially as the temperature decreases and no distinct solid state exists, simplifications are made and approximate analytical equations are derived for the significant ablation parameters. The approximate equations are shown to be extremely accurate for determining the energy absorbed per unit mass of ablated material. The theory treats two physical cases of interest: (1) the ablated material flows without vaporization and (2) partial vaporization occurs. A procedure is suggested for ablation calculations along an arbitrary body contour.

Boundary Layer

THE UNIT REYNOLDS NUMBER AS A PARAMETER IN BOUNDARY LAYER STABILITY. J. D. Whitfield and J. L. Potter. USAF AEDC TN 58-77 [AD 202731], Oct., 1958. 9 pp. 18 refs. Analysis showing that a connection between the unit Reynolds Number and boundary layer transition can be established through the influence of unit Reynolds Number on frequency and energy of oscillations within the boundary layer. From this reasoning it follows that an increased Reynolds Number of transition generally should accompany increases in unit Reynolds Number of the free stream. The analysis demonstrates that a favorable effect of increased unit Reynolds Number in promoting larger values of transition Reynolds Number is predictable in theory and may exist without benefit of surface roughness or leading edge shock induced shear layers. Data measured for a smooth body in subsonic flow are used to support this conclusion.

EXPERIMENTS ON THE USE OF SUCTION THROUGH PERFORATED STRIPS FOR MAINTAINING LAMINAR FLOW: TRANSITION AND DRAG MEASUREMENTS. N. Gregory and W. S. Walker. Gt. Brit., ARC R&M 3083, 1958. 30 pp. 10 refs. BIS, New York, $1.89. Test results indicating that up to wind speed of 180 ft./sec. the suction may be safely applied to external laminar flow, provided the ratio of hole diameter to boundary-layer displacement thickness is less than two, the ratio of hole pitch to diameter is less than three, and there are at least three rows of holes in the strip. With less than three rows, the criteria are much more restrictive. It is possible to extend laminar flow by suction through perforations whose diameters and pitches exceed these values slightly, but only with the risk that excessive suction quantities will produce wedges of turbulent boundary layer originating at the holes.

BOUNDARY LAYER TRANSITION WITH GAS INJECTION. Appendix - PERMEABILITY DISTRIBUTION IN POROUS SURFACE. C. J. Scott and G. E. Anderson. Minn. U. Inst. Tech. RAL Res. Rep. 151 (AFOSR TN 58-786) [AD 202112], July, 1958. 28 pp. 24 refs. Experimental investigation conducted on a porous 16° cone at Mach Number 3.7 to ascertain the effects of gas injection on the stability of the laminar boundary layer. Test facilities and model are described. Graphical representations of results are made. It is shown that the porous cone exhibits transition characteristics similar to very smooth plastic cones. Observed zero-heat-transfer transition Reynolds Numbers decrease with increased injection, but this effect was overcome by the cooling possible with injection.

SIMPLIFIED METHOD FOR DETERMINATION OF CRITICAL HEIGHT OF DISTRIBUTED ROUGHNESS PARTICLES FOR BOUNDARY-LAYER

TRANSITION AT MACH NUMBERS FROM 0 TO 5. A. L. Braslow and E. C. Knox. US, NACA TN 4363, Sept., 1958. 18 pp. Derivation of a single equation which relates the roughness height to a Reynolds Number that is based on the local flow conditions at the top of the particle for a given Mach Number and roughness location. Charts are presented from which the critical roughness height can be obtained. Application has been made to various types of configurations, and in all cases the calculated roughness height caused premature boundary-layer transition for the range of test conditions.

ON GOLDSTEIN'S THEORY OF LAMINAR SEPARATION. K. Stewartson. Quart. J. Mech. & Appl. Math., Nov., 1958, pp. 399-410. Analysis showing that the expansion assumed by Goldstein to describe the flow near separation in a laminar boundary layer is incomplete and that further terms which include powers of logarithms must be added. These terms are individually singular at separation. Although it cannot be inferred that the velocity profile must also be singular at separation, it is suggested that if the boundary layer is to continue downstream of separation the main stream must adjust itself so that these terms cannot appear. The solution may then be continued through separation by means of a power series into a region of reversed flow.

THE THREE-DIMENSIONAL COMPRESSIBLE LAMINAR BOUNDARY LAYER. Appendix A - HYPERSONIC APPROXIMATION TO THREE-DIMENSIONAL STAGNATION POINT FLOW. Appendix B - IMPROVED APPROXIMATION FOR PLANE OF SYMMETRY FLOW. Appendix C - DETAILS OF WING STAGNATION LINE CALCULATIONS. Melvin Epstein. Polytech. Inst. Bklyn., Dept. Aero. Eng. & Appl. Mech., PIBAL Rep. 455 (AFOSR TN 58-894) [AD 204135], Oct., 1958. 77 pp. 30 refs. Presentation of a method to overcome one of the principal difficulties associated with the integral method, namely the problem of choosing appropriate analytical representations of the boundary-layer profiles. This difficulty is magnified in the three-dimensional problem where an additional profile must be specified. In such cases it is desirable that a means of automatically choosing a set of profiles be available. This is accomplished, in the present method, by means of an iteration procedure wherein improved approximations to the boundary layer profiles are generated from a set of simple initial profiles. A comparison of results predicted by the present method with known exact solutions of two- and three-dimensional problems indicates that an iteration is sufficient to obtain engineering accuracy for a wide range of problems.

SOME NUMERICAL SOLUTIONS OF SIMILARITY EQUATIONS FOR THREE-DIMENSIONAL LAMINAR INCOMPRESSIBLE BOUNDARY-LAYER FLOWS. P. L. Yohner and A. G. Hansen. US, NACA TN 4370, Sept., 1958. 76 pp. Presentation of solutions for two classes of similarity equations. The main-flow streamlines for one class of flow are curves on which corresponding points on any two streamlines are related by a constant displacement along one of the coordinate axes. The streamlines for the other set are lines emanating from a point.

EFFECT OF UNIFORMLY DISTRIBUTED ROUGHNESS ON TURBULENT SKIN-FRICTION DRAG AT SUPERSONIC SPEEDS. F. E. Goddard, Jr. J. Aero/Space Sci., Jan., 1959, pp. 1-15, 24. 19 refs. Experimental investigation to determine the effect of uniformly distributed sand-grain roughness on the skin-friction drag of a body of revolution for the case of a turbulent boundary layer. The Mach Number range covered was 1.98 to 4.54, and the Reynolds Number varied from 3×10^6 to 8×10^6. Data for a Mach Number of 0.70 were also obtained. It is shown that at speeds up to Mach 5 and for roughness sizes such that the quadratic resistance law holds, the compressibility effect is indirect and the skin-friction drag is a function of only the roughness Reynolds Number. The entire compressibility effect is a reduction of the fluid density at the surface as the Mach Number increases. Over the range of roughness sizes considered there appears to be no wave drag associated with the drag due to roughness. The shift in the turbulent velocity profile, for a rough surface at supersonic speeds, is a function of the roughness Reynolds Number only and quantitatively follows identically the same law as that for the incompressible case.

Control Surfaces

MEASUREMENTS OF AERODYNAMIC FORCES AND MOMENTS AT SUBSONIC SPEEDS ON A SIMPLIFIED T-TAIL OSCILLATING IN YAW ABOUT THE FIN MIDCHORD. Sh. A. Clevenson and S. A. Leadbetter. US, NACA TN 4402, Sept., 1958. 20 pp. Presentation of coefficients which define rolling moment of the horizontal stabilizer alone and rolling moment, yawing moment, and side force of the complete T-tail. In the investigation the range of reduced-frequency parameter was from 0.09 to 0.56, the Mach Number range from 0.13 to 0.50, and the Reynolds Number range from 0.90×10^6 to 8.21×10^6. Coefficients for the steady case are calculated for the forces and moments and good agreement is indicated for all except the horizontal-stabilizer rolling-moment coefficient which is found to be of greater magnitude than was indicated by steady-state results.

Flow of Fluids

THEORETICAL STUDIES ON STEADY FLUID MOTION UNDER A FREE SURFACE. I - DISTURBANCE OF A MANY-DIMENSIONAL FIELD SATISFYING THE HELMHOLTZ EQUATION DUE TO THE PRESENCE OF A HYPERPLANE BOUNDARY. II - EFFECT OF A FREE SURFACE ON TIME-DEPENDENT FLUID MOTION IN THE PRESENCE OF A BODY. G. C. K. Yeh and J. Martinek. Reed Res. Inc. FR RR-1373, June 30, 1958. 37 pp. Navy-sponsored establishment of a new theorem for expressing, in terms of an undisturbed function, the disturbance function of an n-

dimensional field. In the special case of a field satisfying the Laplace equation in three dimensions the boundary conditions include those in hydrodynamics, heat, magnetism, and electrostatics. The disturbance potential, due to the presence of a slightly curved free surface, is expressed in terms of the potential due to any simply harmonic oscillatory motion of an inviscid, incompressible, and irrotational fluid flow in an unlimited domain. By superposition of such oscillatory potentials, time-dependent potentials for a more general fluid motion under a free surface can be obtained.

LOW-DRAG SPECIFICATION OF SURFACE IRREGULARITIES. J. W. Stuart, Jr. USCEC Rep. 40-203 (AFOSR TN 58-404) [AD 158207], Mar. 31, 1958. 13 pp. Discussion of a convenient form of presenting the relationships between irregular geometry and transition position based primarily on Tani's measurements in semi-infinite flow over a flat plate. Nomographs are obtained which can be utilized for engineering purposes. It is concluded that the determination for an actual body configuration probably can be availed in a practical form of presentation. The flat plate relationship can constitute an adequate approximation for many slender airfoils.

THE SOLUTION OF BOUNDARY VALUE PROBLEMS FOR A GENERAL HODOGRAPH EQUATION. A. G. Mackie. Cambridge Philos. Soc. Proc., Oct., 1958, pp. 538-553. 13 refs. USAF-sponsored analysis of certain boundary problems appropriate to the flow of an inviscid, compressible fluid past a wedge-shaped profile. Expressions are found for the position coordinates and the drag. The resulting solutions are then discussed for functions appropriate to Chaplygin's equation, Tricomi's equation, and the equation of Tomotika and Tamada. The case of Helmholtz flow past a wedge with sonic velocity upstream is treated in detail, and the resulting expressions for the drag enable an estimate to be made of the error which results in using approximations to Chaplygin's equation.

THE HIGH SPEED FLOW OF GAS AROUND BLUNT BODIES. Hyman Serbin. Aero. Quart., Nov., 1958, pp. 313-330. Analysis of previously derived results on the flow of air around blunt bodies moving at high speed. The theory predicts in a satisfactory manner the shock shape and detachment distance for a flat disc and a sphere. It is shown that the density ratio across a normal shock is a useful parameter, combining the effects of both the free stream Mach Number and the ratio of specific heats.

SUPERSONIC WIND-TUNNEL STUDY OF REDUCING THE DRAG OF A BLUFF BODY AT INCIDENCE BY MEANS OF A SPIKE. G. K. Hunt. Gt. Brit., RAE Rep. Aero. 2606, May, 1958. 50 pp. 11 refs. Investigation using a bluff body with a hemispherical nose and fitted with a series of cylindrical spikes with conical tips. Changes in the flow around the nose, caused by the spike, are examined qualitatively by schlieren observation. Effects due to changes of spike proportions, angles of incidence, Reynolds Number, and Mach Number are measured separately in terms of changes in the drag and lift on the body. The greatest drag reduction was 50% at zero incidence, but the spike became less effective as incidence increased. The largest spike diameter is the most effective in reducing drag; the minimum drag occurred at a critical spike length which is a function principally of Reynolds Number, but also of Mach Number, angle of incidence, and the ratio of spike diameter to nose diameter.

EXPERIMENTAL STUDIES AT MACH NUMBERS 12 TO 19 OF CONICAL AND BLUNTED BODIES AT ZERO ANGLE OF ATTACK. S. M. Bogdonoff and I. E. Vas. Princeton U. Dept. Aero. Eng. Rep. 435 (AFOSR TN 58-841) [AD 203181], Sept., 1958. 58 pp. Presentation of pressure distributions and schlieren photographs for bodies with cone half angles varying from 10° to 45°. Comparison with the theoretical inviscid and Newtonian pressures corrected for normal shock losses was made. The pressures on a body without corners can be predicted quite well. A corner at the junction of the nose section and conical afterbody results in large variations between the measured values and predicted ones. The pressures on the conical bodies were not affected by the nose shape for that part of the body downstream of a station located at 1.5 times the nose bluntness diameter.

VELOCITY DISTRIBUTIONS AND SHAPES FOR FREE STREAMLINE BODIES HAVING WEDGE-SHAPED NOSES. Jesse Pierce, J. L. Hess, and A. M. O. Smith. Douglas Rep. ES-29123, Aug. 26, 1958. 50 pp. Analysis of the irrotational flow of an inviscid, incompressible fluid about a class of two-dimensional bodies. These bodies are symmetrical about both their chord line and its perpendicular bisector. Their profile curves are straight lines in the region of the nose and tail. These straight portions are joined by curved portions along which the velocity is constant. The problem consists of finding the velocity distribution on the straight line part of the bodies (the wedge-shaped nose), and finding the shape of the curved part (the free streamline). This is done for ten values of the semiwedge angle, ranging from 1.5° to 105°, and for various values of the ratio of free-streamline velocity to free-stream velocity.

FREE-FLIGHT INVESTIGATION TO DETERMINE THE DRAG OF FLAT- AND VEE-WINDSHIELD CANOPIES ON A PARABOLIC FUSELAGE WITH AND WITHOUT TRANSONIC INDENTATION BETWEEN MACH NUMBERS OF 0.75 AND 1.35. W. L. Kouyoumjian and Sherwood Hoffman. US, NACA TN 4405, Sept., 1958. 34 pp. Study to determine the effects of canopy location, canopy windshield shape, canopy fineness ratio, and transonic area-rule indentation on pressure drag and total drag. The results indicate that moving a 63° swept-back flat-windshield canopy rearward, from near the body nose to the maximum body diameter location, increased the model drag coefficients at transonic and low supersonic speeds. Changing to

a vee-shaped windshield resulted in a negligible change in drag coefficient compared with that for the flat-windshield canopy. When the canopy fineness ratio is changed from 7.00 to 4.50, the drag coefficients obtained for the short canopy are appreciably higher than those for the long canopy. The transonic area-rule indentation proved effective in decreasing the pressure drag of all the canopy-fuselage combinations investigated near a Mach Number of 1.00, but the effectiveness decreased with increasing Mach Number.

A STUDY OF SEVERAL THEORETICAL METHODS FOR COMPUTING THE ZERO-LIFT WAVE DRAG OF A FAMILY OF OPEN-NOSED BODIES OF REVOLUTION IN THE MACH NUMBER RANGE OF 2.0 TO 4.0. Appendix A, B - CALCULATIONS BY METHOD OF CHARACTERISTICS. L. L. Presley and E. A. Mossman. US, NACA TN 4368, Sept., 1958. 61 pp. 15 refs. Comparison of calculations made by six approximate methods — first- and second-order perturbation, generalized shock-expansion, second-order shock-expansion, tangent-wedge, and impact theories — to the values given by the method of characteristics. It is found that second-order perturbation and second-order shock-expansion theories give the best overall agreement with the method of characteristics. For bodies of the type investigated with the same initial lip angle and the same diameter ratio, the wave drag was found to increase sharply for fineness ratios less than 3 but to be nearly constant for fineness ratios above 3. The wave drag was found to decrease nearly linearly as the diameter ratio increased for bodies having the same initial lip angle and fineness ratio.

SIMPLE SHEAR FLOW PAST A FLAT PLATE IN AN INCOMPRESSIBLE FLUID OF SMALL VISCOSITY. Appendix A - ON THE CONDITION OF CONSTANT VORTICITY. Appendix B - DIMENSIONAL ANALYSIS. Ting Yi Li. Rensselaer Polytech. Inst. Dept. Aero. Eng. TR AE5813 (AFOSR TN 718) [AD 162253], July, 1958. 53 pp. 15 refs. Analysis of a problem discussed previously using a new approach to determine whether the simple boundary layer equations that were used contain all the significant terms for a higher order approximation. The existence of an induced pressure gradient due to the displacement thickness effect is also discussed. An approximate method of integration of the Navier-Stokes equations, previously adapted by Lin, is generalized to permit a systematic computation of the solution. It is shown that for the present formulation the flow vorticity ω plays an important role that is usually assigned to the flow velocity u in conventional boundary-layer theory. For higher approximations, only the Navier-Stokes equations provide the correct basis of analysis. The vorticity effects on skin-friction law are also discussed.

TRANSONIC FLOWS PAST SYMMETRICAL AIRFOILS WITH ATTACHED SHOCK WAVE ($M_\infty < 1$). II. Silvio Nocilla. Torino Polytech. Inst. Appl. Mech. Lab. TN 9 (AFOSR TN 58-943) [AD 205083], July, 1958. 24 pp. Extension of previous research to determine the transonic flow in the whole region surrounding the profile. A particular boundary value problem is calculated for the Euler-Poisson equation. An approximate method for the determination of the flow is presented. The developed theory is applied to the study of Tomotika-Tamada's profiles for which the velocity-distribution on the profile, the sonic line, and the shock line are numerically determined.

ANALYSIS OF TURBULENT FLOW AND HEAT TRANSFER IN NONCIRCULAR PASSAGES. Appendix A, B - CONDITION FOR FULLY DEVELOPED HEAT TRANSFER. R. G. Deissler and M. F. Taylor. US, NACA TN 4384, Sept., 1958. 35 pp. 13 refs. Generalization of previous results on turbulent heat transfer and flow in tubes and application to flow in noncircular passages of equilateral triangular and square cross section. Velocity distributions, wall shear-stress distributions, and friction factors, as well as wall heat-transfer distributions, wall temperature distributions, and average heat-transfer coefficients, are calculated. The peripheral temperature variation was assumed small in comparison to the variation of temperature across the passage. Includes a comparison of previously obtained analytical results for the axial flow between rods with new experimental data.

PRESSURE AND LAMINAR HEAT TRANSFER RESULTS IN THREE-DIMENSIONAL HYPERSONIC FLOW. Victor Zakkay. Polytech. Inst. Bklyn., Dept. Aero. Eng. & Appl. Mech. (USAF WADC TN 58-182) [AD 155679], Sept., 1958. 58 pp. 27 refs. Review of the methods of analysis available for the pressure and heat-transfer distribution on axially symmetric cones at different angles of attack. An approximate method for determining the peripheral pressure distribution about axially symmetric blunted cones is developed. The laminar boundary layer theories for three-dimensional compressible flows are discussed. Model design and testing procedure are described. Tests were performed at a Mach Number of 6.0 for various angles of attack, and the results are compared with the existing theories, particularly that of Vaglio-Laurin. A method is included for determining the crossflow velocity gradient from the peripheral pressure distribution.

THE STABILITY OF COUETTE FLOW IN AN AXIAL MAGNETIC FIELD. E. R. Niblett. Can. J. Phys., Nov., 1958, pp. 1,509-1,525. Extension of Chandrasekhar's theory on the stability of viscous flow of an electrically conducting fluid between coaxial rotating cylinders with perfectly conducting walls to the case of nonconducting walls. It is found that their effect is to reduce the critical Taylor Numbers and to increase the wavelength of the instability patterns. An experiment for measuring the values of magnetic field and rotation speed at the onset of instability in mercury between perspex cylinders is described. The radioactive isotopes Hg^{197} and Hg^{203} are used to trace the flow. Results support the theoretical prediction that the boundary conditions can have a large effect on the motion.

PROPAGATION CHARACTERISTICS OF DETONATION GENERATED PLASMAS. Utah U. ERG Rep. (AFOSR TN 58-754) [AD 201613], June 20, 1958. 32 pp. Presentation of electrical conduction measurements on a highly ionized plasma region produced by detonating high explosives. The plasma is determined to originate directly from reactions of the high explosive rather than from thermal ionization associated with the accompanying shock wave. The mechanism of conduction is considered, and it is shown that electron flow through the plasma accounted for practically all of the current. Therefore, it is concluded that the current flow through the plasma region is of the same nature as current flow in metal. Conduction measurements in atmospheres of chlorine, oxygen, nitrogen, helium, and air show that the rate of decay of the plasma is dependent upon the gaseous medium and can be explained on the basis of negative ion formation.

THE RUNAWAY EFFECT IN A FULLY IONIZED PLASMA. E. R. Harrison. Philos. Mag., 8th Ser., Nov., 1958, pp. 1,318-1,325. Study of the conditions for producing runaway electrons in a fully ionized gas by considering Chandrasekhar's coefficient of dynamic friction. The runaway currents emitted continuously from linear plasmas are then estimated and shown to be in general agreement with results from some preliminary experimental work. The rate of increase of runaway currents in closed circuits, such as toroidal plasmas, is estimated and found to be proportional to t^2 (t = time).

THE KINETIC EQUATIONS OF GAS DISSOCIATION INCLUDING DIFFUSION. A. I. Gubanov and Iu. P. Lun'kin. Sov. Phys. - Tech. Phys., Nov., 1957, pp. 2,443-2,450. 13 refs. Translation. Derivation of a set of equations which describe the behavior of a gas in nonequilibrium diffusion and dissociation. The cases of a diatomic gas and air as a five-component mixture are considered. The temperature dependence of the kinetic coefficients for the obtained equations is also studied.

SIMILARITY FLOWS BEHIND STRONG SHOCK WAVES. M. H. Rogers. Quart. J. Mech. & Appl. Math., Nov., 1958, pp. 411-422. Analysis of similarity solutions for three cases of plane, cylindrical, and spherical symmetry. The flow is caused by an expanding piston, and the total energy increases as a power of time. The ratio of kinetic to internal heat energy of gas is computed and it is found that in the case of a piston which is expanding at a uniform rate there is equipartition of energy.

THE EXACT FLOW BEHIND A YAWED CONICAL SHOCK. Appendix A - DETAILS OF SOLUTION. Appendix B - CALCULATION OF LIFT AND DRAG COEFFICIENTS. G. Radhakrishnan. Coll. of Aeronautics, Cranfield, Rep. 116, Apr., 1958. 33 pp. 12 refs. Development of a simple numerical method for solving the differential equations of motion behind the shock wave. Application is made to the case of flow of a perfect gas behind a conical shock of semiapex angle 30°, yawed at 20° to a free stream of Mach Number 10. The shape of the body which would produce such a shock wave is determined. The properties of the flow between the shock wave and the body surface are investigated, particularly with respect to the variation of entropy and the streamline pattern. The existence of a singular generator on the body surface in the plane of yaw and on the "leeward" side, at which the entropy is many-valued, is brought out. It is found that, downstream of the shock, all streamlines curve round and tend to converge to this singular generator.

THE REVOLVING ARM METHOD AND ITS APPLICATION TO RAREFIED GAS DYNAMICS AND AEROTHERMODYNAMICS. F. M. Devienne. Lab. Méditerranéen de Rech. Thermodynamiques TN (EOAFOSR TN 58-769) [AD 201866], May, 1958. 34 pp. Study of the possibilities in using the revolving arm method to measure stagnation temperature and total pressure. The method is limited as to the speed that can be reached, less than Mach 2 in dry air. In the free molecular regime or the transition flow regime the revolving arm method can be applied without correction for Knudsen Number values superior or equal to 0.6 in the case of dry air. At higher pressures, which correspond to lower Knudsen Numbers, it is necessary to make some corrections in order to keep account of the heating of gaseous layers in the vicinity of the arm.

A NOTE ON THE INTERPRETATION OF BASE PRESSURE MEASUREMENTS IN SUPERSONIC FLOWS. R. C. Hastings. Gt. Brit., RAE TN Aero.2572, June, 1958. 20 pp. 27 refs. Review of empirical theory and experimental methods for flow behind the blunt base of a body in a supersonic stream. A discussion of the interpretation of small scale experiments with natural transition from laminar to turbulent boundary layer flow shows that some difficulty may be encountered in deriving base pressure from the base drag at the high Reynolds Number of practical interest. An increase in high Reynolds Number is thought to raise base drag appreciably at Mach Numbers less than 2. Although the empirical methods of estimating base drag are not entirely satisfactory, one, due to Love, is recommended provisionally.

CONTRIBUTION A L'ANALYSE DE LA TURBULENCE ASSOCIEE A DES VITESSES MOYENNES. Antoine Craya. France, Min. de l'Air PST 345, 1958. 111 pp. 24 refs. SDIT, 2, Av. Porte-d'Issy, Paris 15, Frs. 1,480. In French. Analysis of the anisotropic structure of homogeneous turbulence associated with mean velocities assumed to be linearly distributed in space. The equations describing this interaction are derived, the variables reduced by the condition of incompressibility, and the system is further reduced to the case where the mean field is a pure deformation.

Internal Flow

A RAPID METHOD FOR CALCULATING THE "OFF-DESIGN" PERFORMANCE OF COMPRES-

SORS AND TURBINES. J. H. Horlock. Aero. Quart., Nov., 1959, pp. 346-360. Development of an analytical method indicating that the overall performance of a machine may be obtained in an integral form which permits a rapid calculation of performance maps for rotational speeds and flow rates not greatly different from design values. The method may be used in preliminary design studies of multi-stage compressors and turbines.

USE OF SHORT FLAT VANES FOR PRODUCING EFFICIENT WIDE-ANGLE TWO-DIMENSIONAL SUBSONIC DIFFUSERS. D. L. Cochran and S. J. Kline. US, NACA TN 4309, Sept., 1958. 135 pp. 18 refs. Investigation of the use of flat vanes in two-dimensional subsonic diffusers. Using optimum designs of vane installations, high pressure recoveries and steady flows are obtained for diffuser-wall divergence angles up to 42°. Criteria for optimum configurations are developed, indicating that the vanes should be symmetrically arranged in the vicinity of the diffuser throat, and the vane-passage divergence angle should be approximately 7°.

APPLICATION OF THE METHOD OF COORDINATE PERTURBATION TO UNSTEADY DUCT FLOW. S. C. Himmel. US, NACA TM 1439, Sept., 1958. 152 pp. 10 refs. Derivation of solutions, in the form of perturbation series, for unsteady flows in ducts for which the logarithmic derivative of area variation with respect to the space coordinate is a function of the "smallness" parameter of the perturbation series. The technique is applied to the problem of the interaction of a disturbance and a shock wave in a diffuser flow. It is found that, for a special choice of the function describing the disturbance, the path of the shock wave can be expressed in closed form to first order. The method is then applied to the determination of the flow field behind a shock wave moving on a prescribed path in the x, t-plane. Perturbation-series solutions for quite general shock paths are developed. Results are compared to those obtained by means of the method of characteristics.

DARSTELLUNG VON STOSSDIFFUSORPROZESSEN IM p, w-DIAGRAMM. O. Lutz and W. Buschulte. DFL Inst. Strahltriebwerke Bericht No. 100, June, 1958. 25 pp. In German. Development of a graphical procedure, using basic laws of gas dynamics, for calculating oblique compression shocks in plane flow fields. The diffuser processes such as arise in jet engine intakes are studied for the flight Mach Number range of approximately 1.5 to 5.0. The procedure can be extended to include changes in flight or internal aerodynamic conditions; its limitations due to flow inhomogeneities are indicated.

ON THE STRUCTURE OF JETS FROM HIGHLY UNDEREXPANDED NOZZLES INTO STILL AIR. T. C. Adamson, Jr., and J. A. Nicholls. J. Aero/Space Sci., Jan., 1959, pp. 16-24. OOR-sponsored presentation of a method for calculating the position of the first normal shock, or Mach disc, in the jet behind an underexpanded nozzle. In the calculation for a sonic orifice, the axial pressure distribution on the centerline of the flow behind the orifice is used to define a fictitious nozzle extension, and the shock is then assumed to exist at that point where atmospheric pressure would be attained behind the shock -- i.e., the shock is assumed to exist at the end of the fictitious nozzle extension. Physical arguments are then employed to extend this calculation to nozzles with supersonic exit Mach Numbers. The results compare favorably with experimental data. An approximate method for computing the jet boundary up to the point of maximum jet area is also given. However, its validity is limited by the accuracy desired to relatively low nozzle-exit-to-atmospheric-pressure ratios, and relatively low supersonic Mach Numbers at the nozzle exit.

EXPERIMENTAL INVESTIGATION OF AXIAL AND NORMAL FORCE CHARACTERISTICS OF SKEWED NOZZLES. D. J. Carter, Jr., and A. R. Vick. US, NACA TN 4336, Sept., 1958. 40 pp. Investigation, conducted with cold air at jet total-pressure ratios up to 6.5, of normal forces produced by several "skewed" nozzles and a series of ejectors with skewed shrouds discharging into quiescent air. Nozzles were terminated at angles of 30°, 45°, 60°, and 75° relative to the normal plane. For ejectors, diameter ratios varied from 1.05 to 1.45 and spacing ratio from 0.5 to 2.87. Normal forces amounting to 25% of the axial thrust were produced by several skewed nozzles and certain ejector-type nozzles operating at the higher pressure ratios.

PRELIMINARY STUDY OF THE LIGHT SCATTERING TECHNIQUE FOR DETERMINATION OF SIZE DISTRIBUTIONS IN BURNING SPRAYS. Appendix I - PHOTOMETRIC AND ELECTROMAGNETIC NOMENCLATURE AND UNITS. Appendix II - DIFFRACTION OF LIGHT BY A SPHERE. Appendix III - THE TOTAL SCATTERING COEFFICIENT. R. A. Dobbins. Princeton U. Dept. Aero. Eng. Rep. 430 (AFOSR TN 58-822) [AD 202906], July 15, 1958. 54 pp. 18 refs. Discussion of an optical method based on the light diffracted at small angles from the forward direction when a monochromatic beam is incident upon the spray. A description is given of the equipment and of some of the experimental work. An extension of the theory for dilute dispersions with spacially nonuniform concentrations is also presented.

Wings & Airfoils

LOW-SPEED WIND-TUNNEL TESTS OF THE EFFECTS OF VARIOUS LEADING-EDGE MODIFICATIONS ON THE SECTIONAL CHARACTERISTICS OF A THIN WING (6% THICK, R.A.E. 101 SECTION). S. F. J. Butler. Gt. Brit., RAE TN Aero. 2570, June, 1958. 55 pp. Test results showing that all the leading-edge modifications have pronounced effects on the upper surface flow separations. At the test Reynolds Number 2×10^6, the upper surfaces of the basic round-nosed section exhibited a "short bubble" flow up to 5° incidence, above which incidence a "long bubble" developed.

Addition of a row of strakes inhibited the bubble growth and allowed a certain degree of peak negative pressure to occur near the leading edge. Addition of a sharp leading-edge extension caused the "long bubble" flow to develop from immediately above zero incidence. Deflection of the sharp leading edge caused the upper surface flow to remain attached, except for a localized region on the deflected nose, right up to the stall. As a result of the changes in upper surface flow, the chordwise pressure distributions and force and moment characteristics were also altered considerably.

THE FLOW OVER DELTA WINGS AT LOW SPEEDS WITH LEADING EDGE SEPARATION. Appendix - ATTACHMENT LINES ON A FAMILY OF ELLIPTIC CONES. D. J. Marsden, R. W. Simpson, and W. J. Rainbird. Coll. of Aeronautics, Cranfield, Rep. 114, Feb., 1958. 43 pp. 20 refs. Study made on a 40° apex angle delta wing with sharp leading edges to ascertain the details of the flow in the viscous region near the leading edge of the suction surface of the wing. A physical picture of the flow is obtained from surface flow and a smoke technique of flow visualization combined with detailed measurements of total head, dynamic pressure, flow directions, and vortex case positions in the flow above the wing. Surface pressure distributions are also measured and integrated to give normal force coefficients. The results are compared with other theoretical and experimental data. In particular, the normal force coefficients, vortex case positions, and attachment line positions are compared with the theoretical results of Mangler and Smith.

STUDY OF DRAG REDUCTION OF HIGH-WING CONFIGURATIONS AT SUPERSONIC SPEEDS. R. Parthasarathy. Polytech. Inst. Bklyn., Dept. Aero. Eng. & Appl. Mech., PIBAL Rep. 456 (AFOSR TN 58-837) [AD 203001], Oct., 1958. 21 pp. Study of the possibility of drag reduction of wing-body combinations at all practical values of the lift coefficient, by a proper distribution of the body volume. The configurations used are described. It is found that at Mach Number 3.0 and lift coefficient 0.1, for a cone of semi-vertex angle $\theta_c = 5°$, the high-wing configuration gives a drag reduction of 16% over that of the corresponding midwing configuration, whereas the reduction is 6.5% at Mach Number equal to $\sqrt{2}$. Similar comparison for the percentage increase in lift/drag ratio for the above mentioned configurations shows a maximum increase of 34% at a Mach Number equal to 3.0. Numerical results show that the high-wing configuration gives a significant drag reduction as compared to a mid-wing configuration of equal volume, and greater drag reductions are obtained at higher Mach Numbers.

COMPARISON OF SHOCK-EXPANSION THEORY WITH EXPERIMENT FOR THE LIFT, DRAG, AND PITCHING-MOMENT CHARACTERISTICS OF TWO WING-BODY COMBINATIONS AT M = 5.0. R. C. Savin. US, NACA TN 4385, Sept., 1958. 13 pp. Description of tests in the Ames 10-in. x 14-in. supersonic wind tunnel on two wing-body combinations at angles of attack up to 9°. The models consisted of small thin wings mounted on a body composed of an ogival nose of fineness ratio 3 and a cylindrical afterbody of fineness ratio 2. The wings were symmetrically mounted on the cylindrical portion of the body and had triangular and trapezoidal plan forms. Theoretical results obtained by means of the generalized shock-expansion method are compared with experiment.

AEROELASTICITY

THE FLEXURAL VIBRATIONS OF A CUT THIN RING. L. S. D. Morley. Quart. J. Mech. & Appl. Math., Nov., 1958, pp. 491-497. Analysis of vibrations using exact methods. Tabulations are given for the first ten modes of symmetrical and antisymmetrical vibration. The method can be extended to treat many problems of the flexural vibrations of circular arcs.

AN APPROXIMATE ANALYSIS OF NONLINEAR FLUTTER PROBLEMS. S. F. Shen. J. Aero/Space Sci., Jan., 1959, pp. 25-32, 45. 14 refs. Application of the method of Kryloff and Bogoliuboff, based upon the concept of "harmonic balance." A nonlinear system is reduced to an equivalent linear system, in which some of the parameters become functions of the amplitudes of motion. A few examples of wing control surface flutter with nonlinear structural stiffness, as solved by Woolston using an analog computer, are re-examined. The method is next applied to the finite amplitude flutter of buckled panels in a supersonic stream to illustrate its capability in handling cases with many degrees of freedom. Without using the mode approach, it is shown that the nonlinear behavior may be deduced from a knowledge of the linear system, which in this particular case becomes identical to a problem treated by Hedgepeth.

CALCULATION OF FLUTTER DERIVATIVES FOR WINGS OF GENERAL PLAN-FORM. D. E. Lehrian. Gt. Brit., ARC R&M 2961, 1958. 29 pp. 11 refs. BIS, New York, $1.89. Application of the vortex-lattice method to calculate flutter derivatives for a pair of delta wings and an arrowhead wing. Results are compared with theoretical and experimental investigations and show a reasonable accuracy for low aspect ratio wings in incompressible flow.

USE OF THE KERNEL FUNCTION IN A THREE-DIMENSIONAL FLUTTER ANALYSIS WITH APPLICATION TO A FLUTTER-TESTED DELTA-WING MODEL. Appendix A - STRUCTURAL PROPERTIES OF DELTA-WING MODEL. Appendix B - EVALUATION OF ELEMENTS OF DETERMINANTAL FLUTTER EQUATION AND APPLICATION TO A SPECIFIC CONFIGURATION. D. S. Woolston and J. L. Sewall. US, NACA TN 4395, Sept., 1958. 42 pp. Development of a flutter analysis of the Rayleigh-Ritz, or modal, type applied to a delta semispan wing with a leading-edge sweep angle of 45° which fluttered as a cantilever at a Mach Number of 0.85. The obtained converged so-

lutions for the flutter speed are about 5% less than the experimental value when the first three or four natural-vibration modes are used to approximate the flutter mode.

PROCEDURE FOR CALCULATING FLUTTER AT HIGH SUPERSONIC SPEED INCLUDING CAMBER DEFLECTIONS, AND COMPARISON WITH EXPERIMENTAL RESULTS. Appendix - SAMPLE CALCULATIONS ON A 60° FLAT-PLATE DELTA WING. H. G. Morgan, Vera Huckel, and H. L. Runyan. US, NACA TN 4335, Sept., 1958. 32 pp. Development of a method to determine flutter speeds of wings having camber in their deflection modes. The normal coupled vibration modes of the wing are used to derive the equations of motion. Chord deflections of the vibration modes are approximated by polynomials. The aerodynamic forces that are assumed to be acting on the wing are obtained from piston theory and also from a quasi-steady form of a theory for two-dimensional steady flow. Airfoil shape and thickness effect are taken into account. Comparisons are made between the calculations and experimental data for Mach Numbers between 1.3 and 3.0.

ON THE THEORY OF FLUTTER PREVENTION FOR WING-FLAP SYSTEMS. Appendix - STANDARD AIRCRAFT CONFIGURATION USED IN EXAMPLES. J. D. C. Crisp. Australia, ARL S&M Rep. 259, Jan., 1958. 107 pp. 12 refs. Study of the general principles of dynamic balancing, configurational equivalence, modal impedance, and energy-balance kinematics in the prevention of control surface flutter. These are applied to binary wing flap systems and the comparative behavior established of configurations specified in terms of wing modes; nodal line location; flap span, chord, and spanwise station; and simple flap twisting modes. Some attention is given to other parametric effects including those of modal stiffness ratio, flap and wing inertias, aerodynamic damping, and altitude. Some results of a design study of the wing-torsion aileron flutter behavior of an unbalanced aileron are presented. Configurations are compared on the basis of damping at speed of the two aeroelastic modes of the binary system.

GUST LOADING OF RIGID AND FLEXIBLE AIRCRAFT IN CONTINUOUS ATMOSPHERIC TURBULENCE. K. A. Foss and W. L. McCabe. USAF WADC TR 57-704 [AD 142170], Jan., 1958. 141 pp. 71 refs. Presentation of a general method for computing the stresses and accelerations experienced by a rigid or flexible aircraft when responding to the vertical-gust components of continuous atmospheric turbulence. Through the use of theoretical deductions and parametric studies it has been found that power spectral methods give results comparable to discrete-gust methods due to their dependence on statistical measurements of gust velocity. Because of the need for more spectral measurements on the nature of atmospheric turbulence, it is proposed that gust loads criteria be based on random-gust alleviation factors while still making use of design gust velocities obtained from statistical measurements of gust peaks.

MEASUREMENTS OF THE MOTIONS OF A LARGE SWEPT-WING AIRPLANE IN ROUGH AIR. R. H. Rhyne. US, NACA TN 4310, Sept., 1958. 22 pp. Presentation of results of a flight investigation covering the angular and linear motions of an aircraft in rough air for altitudes of 5,000 ft. and 35,000 ft. summarized in the form of sample time histories, power spectra, root-mean-square values, and probability distributions. It is found that, under conditions of light rough air, the dutch roll frequencies were predominant in the lateral motions whereas the short-period pitching frequencies were predominant in the longitudinal motions. A simple procedure is also presented for extrapolating the measurements of the probability distributions and the power spectra to other turbulence conditions.

AN APPROACH TO THE PROBLEM OF ESTIMATING SEVERE AND REPEATED GUST LOADS FOR MISSILE OPERATIONS. Harry Press and Roy Steiner. US, NACA TN 4332, Sept., 1958. 44 pp. 10 refs. Analysis of available information on atmospheric turbulence presented in order to obtain a simple description of the atmospheric turbulence environment appropriate for missile operations. This simplified description is used to derive methods of estimating severe and repeated gust loads in terms of missile response characteristics and operating parameters for given probabilities of exceedance.

MODELING TECHNIQUE AND THEORY FOR AEROELASTIC SIMILARITY IN BLOW-DOWN WIND TUNNEL TESTS. Luigi Broglio. Roma U. Sch. Aero. Eng. Inst. Aero. Construc. Rep. SIAR 30 (EOAFOSR TN 58-902) [AD 204283], Mar., 1958. 135 pp. Presentation of a procedure using two solid wing models of conventional metals to obtain aeroelastic similarity. The aerodynamic characteristics of the actual body are deduced by means of a simple interpolation between two tested models. Optical and electrical devices to determine the angular deflections of the model are described. The results of tests at a Mach Number of 3.01 on a wing model and a wing-tail combination are given for models of three different materials. Comparison is then made with the theoretical values.

AN IMPROVEMENT OF THE MYKLESTAD METHOD FOR FLEXURAL-VIBRATION PROBLEMS. S. Mahalingam. J. Aero/Space Sci., Jan., 1959, pp. 46-50. 10 refs. Presentation of a method of obtaining the next approximation for the natural frequency by means of a simple auxiliary calculation based on the results of a Myklestad table. The basis of the method is the change of natural frequency caused by a small change either in the mass of one particle or in the elasticity of one segment of a flexural system with a finite number of degrees of freedom. This improvement results in a rapid convergence of successive approximations. Various end conditions are considered, and an illustrative example is given.

AIRPLANES

Air Conditioning, Pressurization

SOME ASPECTS OF REFRIGERATION IN SUPERSONIC AIRCRAFT. E. J. Gabbay. RAeS J., Nov., 1958, pp. 769-786. Review of some basic aircraft refrigeration schemes, with particular reference to their performance in high-speed flight and to the power penalties implied in this form of cooling. Essential thermodynamic and performance characteristics are highlighted. The performance characteristics of possible refrigerators for high Mach Number flight are compared and appraised in relation to practical aircraft requirements.

Fuel Tanks

VARIATIONAL SOLUTION OF FUEL SLOSHING MODES. H. R. Lawrence, C. J. Wang, and R. B. Reddy. Jet Propulsion, Nov., 1958, pp. 729-736. Development of a procedure for calculating the natural frequencies and modes of a shallow and a deep tank by applying the Rayleigh-Ritz technique to solve the variational formulation. An approximate procedure for calculating the sloshing modes and frequencies of a tank of intermediate depth, in terms of the solutions for shallow and deep tanks, is suggested. The satisfactory convergence and accuracy of the method are demonstrated by comparison with exact methods in the cases of flat bottomed tanks and 90° conical bottomed tanks.

FUELS & LUBRICANTS

L'EVOLUTION DES CARBURANTS DANS L'AERONAUTIQUE MILITAIRE. Jean Llaty. Docaéro, Sept., 1958, pp. 41-50. In French. Discussion of the evolution of hydrocarbon fuels and the requirements of relevant military specifications. The importance of thermally stable fuels of high hydrogen/carbon ratio for high supersonic speeds is noted; high-energy fuels using boranes and metallic dispersions are discussed; and propulsion by ions, free radicals, or intramolecular energy sources is briefly noted.

INSTRUMENTS

Pressure Measuring Devices

DETERMINATION DE LA FORME DYNAMIQUE DES CAPTEURS DE PRESSIONS PAR L'UTILISATION D'UN TUBE SOUS HAUTE PRESSION A ONDE DE CHOC. M. J. Zucrow and J. R. Osborn. Fusées, July, 1958, pp. 97-103. 13 refs. In French. Description of a method using high-pressure shock tubes to determine the dynamic response of pressure gages, defined as the ratio of output to input signals, for rocket combustion studies. Also includes calibration, calculation of results, and examples of pressure/velocity diagrams for various operating conditions.

MECHANICS

STUDIES ON THE ACCELERATION OF A BODY FROM REST. II - THE DEPENDENCE OF THE DISTANCE TRAVELED AND THE VELOCITY ATTAINED ON THE SHAPE AND INITIAL VALUE OF THE ACCELERATION CURVE FOR CERTAIN FAMILIES OF VELOCITY DEPENDENT ACCELERATIONS. J. L. Hess. Douglas Rep. ES-26708, Nov. 15, 1958. 54 pp. Analysis of the effect on performance of changes in thrust by obtaining the relationship between velocity attained and distance traveled for two families of accelerations, and by examining the way in which this relationship changes when the parameters defining the families are varied. The families considered, which relate acceleration to velocity by means of certain power laws, are sufficiently flexible so that the initial acceleration, final acceleration, and the slope and curvature of the acceleration versus velocity can be varied more or less independently and their individual effects exhibited.

MISSILES

OPTIMIZATION OF SPACE VEHICLE DESIGN WITH RESPECT TO PROPULSION SYSTEM. P. E. Sandorff. MIT Aero. Eng. Dept. ARG Rep. (AFOSR TN 58-580) [AD 158402], July 1, 1958. 9 pp. Analysis concluding that for the case of engine weight proportional to thrust the mission establishes the ideal velocity increment v_i and the initial acceleration factor n_i, and the propulsion system determines effective exhaust velocity C and engine weight k_F. It is apparent that for contemporary chemical rockets, the specific impulse is the most significant factor in the performance of the propulsion system. For space vehicles the v_i requirements are even greater and the need for a significant increase in C is emphasized. There are, however, indications that uninhibited increase in specific impulse is not the answer to all the problems, if the advancement in engine design is not accompanied by a reduction in the specific weight of power-handling components.

OPTIMUM THRUST DIRECTION FOR MAXIMUM RANGE. G. Leitmann. Brit. Interpl. Soc. J., Sept.-Oct., 1958, pp. 503-507. Derivation of the necessary conditions for the existence of an optimum thrust direction in order that a rocket of specified configuration reaches maximum range. Results are applied to a two-stage rocket.

TOPICS IN DYNAMIC PROGRAMMING FOR ROCKETS. Angelo Miele and J. O. Cappellari, Jr. Purdue U. Sch. Aero. Eng. Rep. A-58-5 (AFOSR TN 58-685) [AD 162218], July, 1958. 65 pp. Survey of research covering the following problems: (1) stationary conditions for problems involving time associated with vertical trajectories, computation of a simple approximate relationship between altitude and Mach Number; (2) analysis of the optimum thrust programing for the level flight of rocket powered aircraft, presentation of five different formulations and summarized results; (3) programing of the thrust direction with aerodynamic forces included, a general analytical expression for the optimum inclination of the vector thrust with respect to the vector velocity; (4) programing of the thrust direction and of the thrust modulus in vacuum flight, showing that no

variable-thrust sub-arc may exist, the optimum trajectory only includes zero-thrust and full-thrust sub-arcs; (5) maximum range in vacuum flight for the case where both the initial and final path inclinations are free and the velocity modulus at final point is also free.

NAVIGATION

CELESTIAL OBSERVATIONS FOR SPACE NAVIGATION. Lewis Larmore. (IAS Natl. Summer Meeting, Los Angeles, July 8-11, 1958.) Aero/Space Engrg., Jan., 1959, pp. 37-42. Presentation of three celestial navigation systems giving accuracies sufficient for mid-course location, provided 1/1,000 is used as the ratio between position accuracy and trip length. The most accurate location method consists of a sun-star pair plus a planet-star sight. The selection of a coordinate system is discussed; the equatorial system prevails with the necessary corrections due to the precession of the equinoxes being made. The invariable plane is defined, and the determination of the azimuth angle described. Positional errors due to instrumental limitations and three unknown systematic errors, plus five which can be corrected, are discussed.

INERTIAL NAVIGATION. II. C. F. O'Donnell. Franklin Inst. J., Nov., 1958, pp. 373-402. 24 refs. Study of problems in inertial guidance, such as the choice of coordinate systems, gyrocompass alignment, and platform stabilization. A description is given of gyroscopes and accelerometers, and the operational requirements of each are outlined, as are the characteristics of computers used in inertial navigation. An analysis is made of error contributions from bias, gyro drift, noise, and impulse. Finally the use of information from other navigational systems is discussed.

POWER PLANTS

ELEMENTARY CONSIDERATIONS OF THE DIRECT CONVERSION OF THERMONUCLEAR ENERGY TO ELECTRICAL ENERGY. A. C. Ducati. Plasmadyne Corp. TN E-3TN098-332 (AFOSR TN 58-792) [AD 202225], Sept. 1, 1958. 14 pp. Analysis of certain basic considerations pertaining to the problem of extracting electrical energy from a thermal fusion reactor. The maximum energy that can be expected from certain fuels is first considered, followed by the problem of extracting the energy from the fuel. The basic problem is to convert a fraction of the kinetic energy of the reaction products and the "bremsstrahlung" energy to electrical energy. It is shown that the fusion power balances the "bremsstrahlung" loss when the kinetic temperature of the plasma reaches the so-called critical temperature. The possibility of direct conversion of charged particle kinetic energy to electric energy, by employing the coupling between plasma and magnetic field at the boundary, is discussed.

FUNDAMENTAL INVESTIGATION OF ELECTRICAL POWER SOURCES FOR ELECTRIC THRUST DEVICES — MORPHOLOGY. E. J. Hellund. Plasmadyne Corp. TN E-TN088-332 (AFOSR TN 58-790) [AD 202223], Sept. 3, 1958. 32 pp. Survey and classification of various types of power sources which might possibly be used in conjunction with propulsion systems for space vehicles. The primary goal in the evaluation of all systems is to obtain an unambiguous upper limit to performance equivalent to that derived for heat engines on the basis of the Carnot cycle. It can be seen from the examples given that the basic conservation laws of physics are usually sufficient to settle the problem of feasibility in regard to any proposal.

A NOTE ON "A NUCLEAR ELECTRIC PROPULSION SYSTEM." H. Preston-Thomas. Brit. Interpl. Soc. J., Sept.-Oct., 1958, pp. 508-517. Presentation of solutions valid for various design parameters. Relations using the characteristic velocity for assessing the performance of a rocket are presented. A special case of the exhaust velocity being variable with time is considered. The solutions for the special case of transit with fixed exhaust velocity or a fixed acceleration in field-free space are given and used to derive the characteristics of an ion rocket to which specific design and performance figures have been assigned.

NEUTRONEN UND IONEN ZUM ANTRIEB FÜR RAUMFAHRZEUGE. Günther Au. Raketentech. & Raumfahrtforsch., Oct., 1958, pp. 121-130. 38 refs. In German. Survey covering the discovery of the neutrons and some reactions with nucleus. The most important problems of neutron-physics are discussed, emphasizing the slowing-down effect of neutrons. Includes description of a combination of a fission reactor and an ion source with a magnetic lens system which may be applicable to a propulsion system for space vehicles. Results of measurements on electron focusing through two hyperbolic quadrupole magnets are also presented.

Jet & Turbine

AN APPROXIMATE METHOD OF DETERMINING THE VIBRATION ANGLE OF TURBOBLADING WITH LASHING WIRE. M. M. Stanišić. Forschung Gebiete Ing., Ausg. A, No. 5, 1958, pp. 154-160. Development of a method for the analytical determination of the eigenvector direction in which a group of blades will vibrate in the fundamental bending mode. The theory is based on the variational principle of strain energy and it is assumed that the turbine blades act as a cantilever beam without taper, have a constant cross section, and are twisted along their length. The structural damping is neglected and the effect of centrifugal forces is not taken into account. Results indicate that, in the case of one connection, the eigenvector direction differs very little from the direction of the axis of maximum moment of inertia. Possible extension of the analysis is presented in detail.

THEORETICAL AND EXPERIMENTAL ANALYSIS OF THE REDUCTION OF ROTOR BLADE VIBRATION IN TURBOMACHINERY THROUGH THE USE OF MODIFIED STATOR VANE SPACING. R. H. Kemp, M. H. Hirschberg, and W. C. Mor-

gan. US, NACA TN 4373, Sept., 1958. 43 pp. Theoretical analysis indicates that the vibration excitation originating in the stator vane assemblies of turbomachinery can be reduced 68% by altering the circumferential positions of the individual vanes in a prescribed manner by amounts less than ±10% of the normal spacing. Experimental verification of the analysis is obtained by using an air-interrupter disc and measuring the amplitudes of vibration of turbine blades in a turbojet when two different stator vane assemblies are used.

REVIEW OF HIGH-TEMPERATURE IMMERSION THERMAL SENSING DEVICES FOR IN-FLIGHT ENGINE CONTROL. V. D. Sanders. Rev. Sci. Instr., Nov., 1958, pp. 917-928. 52 refs. Survey of sensing devices used for monitoring and control of modern aircraft propulsion units. Typical performance and thermoelectric behavior of twenty metallic thermocouples calibrated above the melting point of platinum are presented. Seven of these pairs have been taken above 4,000°F. and nine additional combinations have been calibrated above 3,500°F. A comparison is made of the calibration atmospheres, maximum outputs, estimated maximum errors, temperature ranges of calibration, and ultimate temperature ranges. A review of methods and properties of refractory oxides suitable for thermocouple protection at high temperatures is also presented.

Ram-Jet & Pulse-Jet

AN ANALYSIS OF RAMJET ENGINES USING SUPERSONIC COMBUSTION. R. J. Weber and J. S. MacKay. US, NACA TN 4386, Sept., 1958. 49 pp. Calculation of the performance of ram-jet cycles utilizing supersonic combustor velocities for a range of flight Mach Numbers from 4 to 7. Depending on the inlet characteristics assumed, the supersonic-combustion engine tends to become more efficient than a conventional ram-jet as the flight speed is increased. The effects of parameters such as inlet design, combustor area, divergence, wall friction, and nozzle performance are considered. Estimates of engine weight and cooling levels are included.

RESEARCH, RESEARCH FACILITIES

Wind Tunnels

REIBUNGSWIRKUNGEN BEIM ROHRWINDKANAL. E. Becker. Max-Planck-Inst. Strömungsforsch. Mitteil. No. 20, 1958. 76 pp. 16 refs. DM 8. In German. Theoretical study of the viscosity effects in a tube wind tunnel. Includes derivation of simplifying assumptions used in the calculation of these perturbations for the turbulent boundary layer. An experimental investigation on a model wind tunnel is described and agreement between theory and experiment is confirmed. The theory of the boundary layer growth is based on the momentum law and the calculations on linearized motion and continuity equations.

A STUDY OF THE FEASIBILITY OF THE DIRECT CONDENSATION OF A SUPERSONIC STREAM. Appendix - DESIGN CRITERIA FOR THE VAPOR-LIQUID TWO-PHASE WIND TUNNEL. Howard Wong and J. C. Williams, III. USCEC Rep. 56-204 (AFOSR TN 58-712) [AD 162247], July 31, 1958. 29 pp. Development of a pilot model wind tunnel to study the possibility of using direct condensation (into a liquid) of a supersonic jet to sustain flow in a wind tunnel. The tunnel, using ethyl alcohol as the working fluid and liquid nitrogen as the coolant, was designed for Mach Number of 3, stagnation pressure of 4.07 mm. Hg, and stagnation temperature of 350° K.

SHOCK TUBES. I - THEORY AND PERFORMANCE OF SIMPLE SHOCK TUBES. I. I. Glass. II - PRODUCTION OF STRONG SHOCK WAVES; SHOCK TUBE APPLICATIONS, DESIGN, AND INSTRUMENTATION. J. G. Hall. UTIA Rev.12, Pts. I, II, May, 1958. 336 pp. 111 refs. Study of flows and wave interactions in simple shock tubes. Tables and graphs are presented for use in the determination of flow quantities in perfect and imperfect inviscid gases. Flow deviations induced by viscosity and heat transfer are considered. A comparison is made of predicted and observed flows including effects produced by the nonstationary boundary layer. Production of strong shock waves and their application to hypersonic shock tunnels and aerophysical research are discussed along with shock tube materials and construction.

ROTATING WING AIRCRAFT, HELICOPTERS

SOME STATIC LONGITUDINAL STABILITY CHARACTERISTICS OF AN OVERLAPPED-TYPE TANDEM-ROTOR HELICOPTER AT LOW AIRSPEEDS. R. J. Tapscott. US, NACA TN 4393, Sept., 1958. 27 pp. Comparison of the flight measurements with estimates of the characteristics based on theoretical interference effects. It is shown that the large undesirable trim change with power found in a particular range of conditions can be studied to advantage by using available information on interference effects between rotors.

FLIGHT MEASUREMENTS OF THE VIBRATION EXPERIENCED BY A TANDEM HELICOPTER IN TRANSITION, VORTEX-RING STATE, LANDING APPROACH, AND YAWED FLIGHT. J. E. Yeates. US, NACA TN 4409, Sept., 1953. 20 pp. Test results indicating that for the transition region the peak vibration occurs in the forward-speed range where the interference induced flow is expected to be rapidly changing and might be expected to influence vibration. The vibration measured in the vortex-ring state is characterized by a large irregular pulsing of the vibration envelope at a random frequency, which probably indicates shedding of the vortices. In forward flight at 40 knots the vibration is reduced by a factor of about three at the rear rotor and is only slightly reduced at the front rotor when the helicopter is yawed to an angle of about 23°.

STRUCTURES

THEORY OF STRUCTURAL DESIGN. Appendix A - CURVILINEAR COORDINATES. Appen-

dix B - DEFORMATION AND EQUILIBRIUM CONDITIONS IN ORTHOGONAL CURVILINEAR COORDINATES. W. S. Hemp. Coll. of Aeronautics, Cranfield, Rep. 115, Aug., 1958. 63 pp. Review of classical results on the theory of structures and their current applications. A brief history of previous contributions to the subject is given. Includes development of a mathematical theory for the two-dimensional case and derivation of a number of special solutions. Maxwell's and Michell's theorems are considered, Cox's solutions for a number of symmetrical cases are illustrated, the theory for a plate is developed, and an alternative approach presented. Suggestions for future research are also made.

THEORY OF AIRCRAFT STRUCTURAL ANALYSIS. B. Langefors. ZFW, Oct., 1958, pp. 281-291. 38 refs. Description of modern matrix methods for the analysis of aircraft structures. The basic theory is developed on an algebraic model in which the representation of the basic elements and their connections enter as axioms. A certain reciprocity relation called "cotransference" is developed and used as a basic tool to replace classical energetic concepts. Several methods for practical application are described. These cover piecewise solution, modification of structure, solution of equations, routine checking, and approximate solution.

MATRIX ANALYSIS OF SHELL STRUCTURES WITH FLEXIBLE FRAMES. J. S. Przemieniecki. Aero. Quart., Nov., 1958, pp. 361-394. 13 refs. Development of a simple matrix method for the deflection and stress analysis of cylindrical shell structures of arbitrary cross section stiffened by flexible frames. The method is an extension to fuselage structures of the matrix force method in which the internal load system in the structure consists of two parts: (a) synthetic load distribution and (b) self-equilibrating load systems. The analysis is applied to cut-out problems in fuselage structures and can be used for problems involving thermal loading and diffusion of loads in curved panels stiffened by flexible frames.

Cylinders & Shells

NOTE ON STRESS-STRAIN RELATIONS FOR THIN ELASTIC SHELLS. J. K. Knowles and Eric Reissner. J. Math. & Phys., Oct., 1958, pp. 269-282. ONR-supported generalization of certain higher approximation theories to arbitrary orthogonal middle surface coordinates using the transformation formulas derived previously. The problem of improvements of Love's first approximation theory is analyzed and consideration is given to an inadequacy of this theory insofar as rigid body displacements of the shell are concerned. This inadequacy is shown to be eliminated in the higher approximation theories. An additional inadequacy of Love's theory is found in the case of fundamental problems for helicoidal shells.

TORSION AND FLEXURE OF SOLID CYLINDERS WITH CROSS-SECTIONS TRANSFORMABLE TO A RING-SPACE. R. M. Morris and F. J. Hawley. Quart. J. Mech. & Appl. Math., Nov., 1958, pp. 462-477. Solutions for the potential functions, torsional constant, and center of flexure are determined in the general case, and particular values of these are found for the elliptic cylinder and a cylinder having a circular arc as an internal cut.

FLEXURAL VIBRATIONS OF A THIN-WALLED CYLINDER OF RECTANGULAR CROSS SECTION. E. H. Mansfield. Aero. Quart., Nov., 1958, pp. 331-345. Study of the natural transverse vibrations of a long cylindrical box of doubly symmetrical rectangular cross section. Explicit stress-function solutions are obtained for the webs and the top and bottom surfaces so that the effects of shear lag and shear deflection are inherently included. The results are expressed simply in terms of an effective flexural rigidity which may be determined by means of graphs.

THE INFLUENCE OF FRAME PITCH AND STIFFNESS ON THE STRESS DISTRIBUTION IN PRESSURISED CYLINDERS. D. S. Houghton. Coll. of Aeronautics, Cranfield, Note No. 79, Feb., 1958. 16 pp. Analysis of the stresses occurring in stringer reinforced cylinders due to the restraining action of the frames. Graphs are presented showing the effect of variation in frame pitch and stiffness on the bending moment and shear force in the skins, and on the hoop stress in the skins between frames. Some advantage seems to be gained by using relatively close spaced frames in pressure cabin design, since such frames serve to substantially reduce the maximum hoop stress in the skins, which could be used either to reduce the skin thickness or to increase the critical crack length.

Elasticity & Plasticity

ON PRAGER'S HARDENING RULE. R. T. Shield and Hans Ziegler. ZAMP, Sept. 25, 1958, pp. 260-276. 10 refs. ONR-sponsored evaluation of the initial yield condition, the flow rule, and the hardening rule necessary to describe the behavior of a rigid-work-hardening material. Includes discussion of Prager's hardening rule and its implications for special states of stress prevalent in practical application and evaluation of Hodge's approach using a strain-hardening rule which is a combination of the Prager rule and isotropic hardening. The advantages of Tresca's yield condition are emphasized and the drawback represented by the deformation of the yield surface found in many cases is indicated.

TRANSVERSE WAVES IN ELASTIC PLATES. V. T. Buchwald. Quart. J. Mech. & Appl. Math., Nov., 1958, pp. 498-508. Derivation of expressions for the phase and group velocities of plane rotational waves in elastic plates with displacement vector parallel to the surfaces of the plates and perpendicular to the direction of propagation. It is shown that in a double plate two types of transverse waves can travel along the plate, each type

consisting of an infinite number of modes. The behavior of the waves is illustrated by dispersion curves, computed for the lowest modes. An investigation of the properties of Love waves in a surface layer, including a discussion of the behavior of the minimum group velocity, is also presented.

Plates

ANALYSIS OF THE CREEP BEHAVIOR OF A SQUARE PLATE LOADED IN EDGE COMPRESSION. Appendix A - DERIVATION OF INITIAL CONDITIONS. Appendix B - RESULTS OF EVALUATION OF INTEGRALS REQUIRED FOR CALCULATIONS. H. G. McComb, Jr. US, NACA TN 4398, Sept., 1958. 42 pp. 12 refs. Approximate solutions for a plate assumed to be made of material which obeys a nonlinear creep law. The theory does not yield a finite collapse time but indicates how lateral deflections and unit shortening due to creep might be calculated. The results also show that creep can cause significant redistribution of the middle-surface stresses in a plate.

STRESS CONCENTRATIONS IN A STRIP UNDER TENSION AND CONTAINING AN INFINITE ROW OF SEMICIRCULAR NOTCHES. Akira Atsumi. Quart. J. Mech. & Appl. Math., Nov., 1958, pp. 478-490. Calculation of stress concentration by a perturbation method for several cases, varying the radius of the notches and the distance between the centers of neighboring notches. The decrease in stress concentration is studied and compared with the results for an infinite strip under tension and containing two semicircular notches placed symmetrically on the edges. It is also compared with the stress concentrations in the similar problems of an infinite strip or semi-infinite plate with notches under tension.

Sandwich Construction

HEAT TRANSFER AND THERMAL STRESSES IN SANDWICH PANELS. Appendix A - CONDUCTION OF HEAT IN SANDWICH PANELS. Appendix B - ANALYTICAL APPROXIMATION WITH RADIATION AND CONDUCTION. R. T. Swann. US, NACA TN 4349, Sept., 1958. 34 pp. Calculation of both the maximum temperature differences between faces and the thermal stresses for sandwich panels with a prescribed linear rate of temperature rise at one face and with the other face insulated. Effects of conduction and radiation are included. Maximum temperature differences between top and bottom faces are considerably smaller when both radiation and conduction are considered than when radiation is neglected. The calculated data are used to derive an equation relating two cases of maximum temperature difference: (a) when radiation is included and (b) when only conduction is considered.

Wings

OPTIMUM DESIGN OF A MULTICELL BOX SUBJECTED TO A GIVEN BENDING MOMENT AND TEMPERATURE DISTRIBUTION. Appendix LIMITATIONS ON THE ANALYSIS BY VARIOUS ASSUMPTIONS. D. J. Johns. Coll. of Aeronautics, Cranfield, Note No. 82, Apr., 1958. 35 pp. 12 refs. Development of an interative method by which the optimum geometry of a multicell box of given depth can be found in order to sustain bending and thermal stresses. The advantage of this analysis is that skin thickness may or may not be specified initially by stiffness requirements. In the former case the solution is more easily obtained.

THERMODYNAMICS

SHOCK-TUBE STUDIES OF ACETYLENE DECOMPOSITION. W. J. Hooker. CIT Guggenheim Jet Propulsion Cen. TR 7 (AFOSR TN 58-293) [AD 154202], Apr., 1958. 17 pp. Experimental studies on the rate of decomposition of argon-acetylene mixtures by means of shock waves. Shock velocities were determined to within $\pm$ 1/2%. Activation energies of 26 and 33 kcal/mole, respectively, have been found for the first- and second-order decomposition reactions of acetylene. A curve of temperature versus induction time for carbon formation is established. It is shown that a better correlation is obtained for decomposition reactions of order $n = 1$ and $n = 1.5$ than for $n = 2$. The corresponding activation energies are 10, 13, and 16 kcal/mole, respectively. The effects of impurity and diluent gas radiation, as well as molecular and solid particle light scattering, are negligible.

ÜBER DIE TEMPERATURABHÄNGIGKEIT DER SPEZIFISCHEN WÄRME VON GASEN BEI KONSTANTEM DRUCK. W. Koeppe. Forschung Gebiete Ing., Ausg. A, No. 5, 1958, pp. 161-164. 18 refs. In German. Application of the equation of state and the integral Thomson-Joule effect to study the temperature dependence of the specific heat of gases at constant pressure. It is shown that for each gas a lower and an upper limiting temperature exists at which the specific heat at constant pressure reaches its value for zero pressure at the pressure investigated. In the region between these two limiting temperatures, the specific heat, at the given pressure, exceeds its value for zero pressure.

Combustion

THEORY OF BURNING OF A LIQUID FUEL DROP. F. A. Agafanova, M. A. Gurevich, and I. I. Paleev. Sov. Phys. - Tech. Phys., Aug., 1957, pp. 1,689-1,695. Translation. Presentation of approximate calculations that allow significant conclusions to be made on the burning process of a liquid fuel. Several simplifying assumptions are made. The process is described by three differential equations and their boundary conditions. The equations are reduced in terms of a single dimensionless variable. Temperature field, evaporation rate, and the degree of vapor burning are considered. It is concluded that although the diffusion theory gives an evaporation rate which agrees with experiment, this cannot be considered proof of the purely diffusive character of the burning process of a liquid fuel. Almost the same evaporation rates are obtained when the finite chemical reaction rate is

XUM

taken into account. The chemical reaction rate leads to a much lower calculated value of the maximum temperature with the same evaporation rate. It also gives a calculated maximum temperature zone lying closer to the liquid surface. By accounting for the chemical reaction rate it is possible to analyze the ignition and extinction conditions of liquid fuels.

COMPARISON OF ANALYTICAL METHODS FOR THE CALCULATION OF LAMINAR FLAME VELOCITY. G. Millán and I. Da Riva. Inst. Nac. Tec. Aero. Esteban Terradas Rep. (AFOSR TN 58-812) [AD 202357], June, 1958. 20 pp. Study of methods to calculate laminar flame velocity for the case of second-order reaction where the ratio of diffusion coefficient to thermal diffusivity of the mixture is different from unity. The values obtained analytically are compared for some typical cases with those derived from an extension of von Kármán's method and with values obtained through a numerical integration of the flame equations. The deviation obtained from the analytical method proposed is seen to be smaller than 1% for the case under study which appears to be unfavorable due to the small reduced activation temperature.

A STUDY OF THE KINETICS OF THE HYDROGEN-OXYGEN REACTION IN A NEW FLOW REACTOR. R. J. Swigart. Princeton U. Dept. Aero. Eng. Rep. 432 (AFOSR TN 58-823) [AD 202907], Aug. 15, 1958. 81 pp. 21 refs. Study of the kinetics of the hydrogen-oxygen reaction in the presence of large concentrations of nitrogen. Experimental apparatus and procedure are described, and the range over which the investigation was carried out is stated. The feasibility of a flow reactor using the traversing thermocouple detection system for the present study is shown. A global rate law correlating the data over the range of variables in which the reaction lends itself to study may be applied. Results indicate that the reaction rate increases while the activation energy and ignition lag times decrease with a decrease in reactor diameter. The activation energy decreases with increase in nitrogen concentration. Thus, the walls of the reactor play a significant role in the reaction mechanism in that they exert both a catalytic and a chain breaking effect.

PREDICTION OF THE PROPAGATION VELOCITY OF LAMINAR FLAME SUPPORTED BY A SECOND-ORDER REACTION. J. M. de Sendagorta. Inst. Nac. Tec. Aero. Esteban Terradas Rep. (AFOSR TN 58-770) [AD 201867], Apr., 1958. 10 pp. Development of a method for computing the flame velocity of a second-order reaction supported by diffusion with the Lewis-Semenov Number ranging between 0.5 and 2. The method approximates the degree of advancement of the reaction in the diffusion equations through the exponential approximation. In order to expedite computations a logarithmic diagram is provided giving the values for the integrals more frequently used in the application of the exponential method. The solution introduces throughout the interval a deviation of the order of 1% with respect to the available exact values for a reduced activation temperature.

VTOL & STOL

USE OF THE COANDA EFFECT FOR JET DEFLECTION AND VERTICAL LIFT WITH MULTIPLE-FLAT-PLATE AND CURVED-PLATE DEFLECTION SURFACES. Appendix A, B - ESTIMATED PERFORMANCE OF MULTIPLE-FLAT-PLATE DEFLECTORS, T. F. Gelder. Appendix C - PRESSURE DISTRIBUTION OVER DEFLECTION PLATES. Appendix D - EFFECT OF JET-STREAM TOTAL-PRESSURE LOSSES ON DEFLECTION-PLATE PRESSURE DISTRIBUTION AND LIFT CAPABILITY. U. H. von Glahn. US, NACA TN 4377, Sept., 1958. 54 pp. Test results on Coanda nozzles show a 90° deflection of the jet stream with vertical-lift values of the order of 0.88 and 0.81, respectively, of the undeflected thrust. These lift values are accompanied by an essentially zero axial-thrust component. The measured lift values are not considered to be optimum for a Coanda nozzle, higher values possibly being attainable with more refined deflectors.

EFFECTS OF GROUND PROXIMITY ON THE THRUST OF A SIMPLE DOWNWARD-DIRECTED JET BENEATH A FLAT SURFACE. K. P. Spreemann and I. R. Sherman. US, NACA TN 4407, Sept., 1958. 39 pp. Investigation to determine the effects of some of the basic parameters on jet thrust. Some of the principal variables investigated were size, shape, and aspect ratio of the flat plate, distance of the plate and nozzle exit above the ground, and surface conditions of the ground. Apparatus and methods used are described. Results indicate that reductions in the ratio of plate area to jet area greatly lower the height above the ground where serious adverse ground effects are encountered. Changes in plate aspect ratio from 1 to 3 have little effect on the induced negative thrust in close proximity to the ground, but at 3 and above significant reductions in the thrust are obtained. Extending the nozzle below the flat plate has little effect on the induced negative thrust. Of all the devices tested to reduce the adverse ground effects, a perforated plate raised slightly above the ground was the most effective.

THE STABILITY OF FLYING PLATFORM TYPE HELICOPTERS. T. Opatowski. Helicopter Assn. Gt. Brit. J., Oct., 1958, pp. 238-262. Investigation of flying platforms in order to show the effects of weight, inertia, rotor forces, and pilot response on the ease of control and stabilization. The stabilizing actions of the pilot are assumed to take the form of controlling moments at his ankles in linear response to errors in his attitude, rate of change of attitude, horizontal velocity and horizontal acceleration, the constants of proportionality being termed control constants. The magnitude of the maximum delay time, d_{max}, is a good measure of the stability of the machine and of the ease with which it can be flown. It is increased by increasing the moments of inertia of the platform system and decreased by increasing the weight or center of gravity height of the pilot or by lag of the thrust vector behind the shaft axis. Negative lag increases the range of available control constants and d_{max} and increases the maneuverability.

1958, pp. 337–343. 29 refs. Review of research on the pinch effect and discussion of its application to fusion power.

Nuclear Radiation Effects on Materials: Review of Basic Principles and Summary of Current Knowledge. Gerald Reinsmith. *ASTM Bul.*, Sept., 1958, pp. 37–47. 43 refs.

Nuclear Radiation Effects on Components. T. E. Mount. *Electronic Des.*, Oct. 15, 1958, pp. 18–21. 14 refs. Discussion of the radiation effects on semiconductors, resistors, and capacitors. Procedures to circumvent the radiation problem are described.

Parachutes

Parashiut—SredstvoVozvrashcheniia Cheloveka na Zemliu iz Kosmicheskogo Poleta. N. A. Lobanov. *Vestnik Vozdushnogo Flota*, July, 1958, pp. 44–46. In Russian. Discussion of the application of parachutes as means of returning to earth from cosmic flight. Includes a brief survey of experiments made in USSR.

Photography

Photographic Emulsions for Missile Photography. H. K. Howell. *Photographic Sci. & Eng.*, Aug., 1958, pp. 95–104. AFOSR-sponsored study of 10 black-and-white and three color films for long-range missile photography.

Optique de la Photographie Sous-Marine. Claudine Maureau. *France, Min. de l'Air NT 74*, 1958. 104 pp. SDIT, 2 Av. Porte-d'Issy, Paris 15, Frs. 1,800. In French. Survey of previously applied methods of aerial photography, description of new equipment designed specifically for underwater photography, and evaluation of experimental results.

A Continuous Rapid-Processing System for Side-Looking Radar Mapping. E. D. Seymour. *Photographic Sci. & Eng.*, Aug., 1958, pp. 91–94.

Projection of Photographic Data Recording Two-Tenths Second After Exposure. Carl Orlando. *Photographic Sci. & Eng.*, Oct., 1958, pp. 142–147.

Photographic Technique for Measuring Temperatures in Luminous Rocket Exhaust Flames. F. S. Simmons and A. G. DeBell. *OSA J.*, Oct., 1958, pp. 717–721.

Improved, Single Flash, Continuum Source for Use Below 2000 A. J. A. Golden and A. L. Myerson. *OSA J.*, Aug., 1958, pp. 548–550. USAF-supported description of a low-energy, high-intensity flash lamp.

Physics

Rotation of a Plasma. V. G. Stepanov, V. F. Zakharchenko, and V. S. Bezel. (*Zhurnal Teoret. i Exper. Fiz.*, Feb., 1958, pp. 512, 513). *Sov. Phys.-JETP*, Aug., 1958, p. 353. Translation. Experimental investigation on the possibility of producing a rotational magnetic field.

Ob Odnom Metode Integrirovaniia Granichnykh Nestatsionarnykh Lineinykh Zadach o Rasprostranenii Vozmushchenii v Neideal'no Uprugikh Sredakh. E. I. Shemiakin. *Prikl. Mat. i Mekh.*, May-June, 1958, pp. 289–300. 19 refs. In Russian. Development of a method for the integration of linear, nonstationary, boundary problems covering the diffusion of disturbances in nonideal elastic media.

Energy Moment Treatment of the Quantum Mechanical Asymmetric Rotator. P. M. Parker and L. C. Brown. *Ohio State U. Res. Found. (P-563) TN 6 (AFOSR TN 58-371) [AD 154-277]*, Mar., 1958. 103 pp. 47 refs.

Ob Odnoi Klassicheskoi Modeli Indefinitnoi Metriki. B. V. Medvedev and M. K. Polivanov. *AN SSSR Dokl.*, Aug. 1, 1958, pp. 623–626. In Russian. Evaluation of a method using the indefinite metric for problems of quantum field theory.

Razvitie Metoda Opredeleniia Vremeni Relaksatsii Vozbuzhdennogo Kolebatel'nogo Sostoianiia Molekul s Pomoshch'iu Spektrofona. P. V. Slobodskaia. *AN SSSR Dokl.*, June 21, 1958, pp. 1,238–1,241. In Russian. Development of a spectrophone method for determining the relaxation time of the excited vibration state of molecules.

Infra-Red Radiation. G. B. B. M. Sutherland. (*IEE Paper 2608*) *IEE Proc., Pt. B*, July, 1958, pp. 306–316. 35 refs. Historical review of developments in infra-red techniques, and discussion of some current applications.

Pressure Modulation of Infrared Absorption. I—Entire Vibration-Rotation Bands. J. C. Gilfert and Dudley Williams. *OSA J.*, Nov., 1958, pp. 765–769. USAF-supported research.

Apparatus for the Measurement of Band and Total Absorptances of Gases. *U. Calif. Inst. Eng. Res., Ser. 118/11 (AFOSR TR 58-102) [AD 162225]*. June 30, 1958. 64 pp. 26 refs.

Distribution of Radiation from Elliptical and Parabolic Mirrors. P. J. Hart. *OSA J.*, Sept., 1958, pp. 637–642. 17 refs.

On the Axial Phase Anomaly for Microwave Lenses. G. W. Farnell. *OSA J.*, Sept., 1958, pp. 643–647. 19 refs. USAF-supported research.

Simple Wide Range Specular Reflectometer. R. F. Weeks. *OSA J.*, Nov., 1958, pp. 775–777. USAF-supported development.

Cosmic Rays in the Earth's Magnetic Field. P. Rothwell. *Philos. Mag., 8th Ser.*, Sept., 1958, pp. 961–970. 12 refs. Experimental verification showing that the values of cosmic ray cut-off momenta in the earth's magnetic field, observed at many different places, are generally close to the values calculated from Störmer's theory for the motion of charged particles in a dipole field, if the usual center dipole of the earth is replaced in the Störmer equation by a dipole whose magnitude and direction are determined by the surface field at the place considered.

The Variation of Sea Level Cosmic Ray Intensity Between 1954 and 1957. A. G. Fenton, K. B. Fenton, and D. C. Rose. *Can. J. Phys.*, July, 1958, pp. 824–839. 11 refs.

A Cosmic Ray Increase Related to Solar Activity. J. Katzman. *Can. J. Phys.*, July, 1958, pp. 807–814. 14 refs. Investigation at Ottawa, Canada, to study the variations in intensity of particles coming from a small portion of the sky.

Izmerenie Kosmicheskogo Izlucheniia na Iskustvennom Sputnike Zemli. S. N. Vernov, N. L. Grigorov, Iu. I. Logachev, and A. E. Chudakov. *AN SSSR Dokl.*, June 21, 1958, pp. 1,231–1,233. In Russian. Presentation of preliminary data on cosmic radiation obtained from the second Soviet satellite.

O Primenenii Mnogokaskadnykh Elektronnooptícheskikh Usilitelei Sveta v Astrofizike. M. M. Butslow, E. K. Zavoiskii, A. A. Kaliniak, V. B. Nikonov, V. V. Prokof'eva, and G. E. Smolkin. *AN SSSR Dokl.*, Aug. 11, 1958, pp. 815–818. In Russian. Application of multistage electron optical light amplifiers in astrophysics.

Analysis of Meteoric Body Doppler Radar Records Taken During a Geminid Shower Period. M. S. Rao. *Can. J. Phys.*, July, 1958, pp. 840–854. 27 refs.

Istochniki Zvezdnoi Energii i Evoliutsiia Zvezd. A. Unzol'd. (*DGN 90th Meeting, Hamburg, Sept. 24, 1956.*) *Uspekhi Fiz. Nauk*, July, 1958, pp. 499–520. 40 refs. In Russian. Discussion covering the structure and evolution of the universe, including such factors as cosmic distances, sources of stellar energy, and spectroscopic problems of stellar evolution.

Obshchii Sluchai Statsionarnogo Raspredeleniia Vidimoi Plotnosti v Golove Komety pri Uslovii Postoiannoi Izotropnoi Emissii. D. O. Mokhnach. *AN SSSR Dokl.*, June 21, 1958, pp. 1,228–1,230. In Russian. Study covering the general case of stationary apparent density distribution in the head of a comet in the presence of constant isotropic emission.

Theory of the Echelette Grating. II, III. J. H. Rohrbaugh, R. D. Hatcher, Charles Pine, and W. G. Zoellner. *OSA J.*, Oct., 1958, pp. 704–709, 710, 711. 10 refs. USAF-sponsored research.

Electronic-Recording, Time-Resolving Spectrometer. Per Gloersen. *OSA J.*, Oct., 1958, pp. 712–716. USAF-supported research.

The Knight Shift in Superconductors. V. Heine and A. B. Pippard. *Philos. Mag., 8th Ser.*, Sept., 1958, pp. 1,046–1,050.

On the Galvanomagnetic, Thermomagnetic, and Thermoelectric Effects in Isotropic Metals and Semiconductors. Appendix—**Estimation of Two-Band Model Parameters.** E. J. Moore. *Australian J. Phys.*, June, 1958, pp. 235–254. 15 refs.

Crater Formation in Metallic Targets. W. S. Partridge, H. B. Vanfleet, and C. R. Whited. *J. Appl. Phys.*, Sept., 1958, pp. 1,332–1,336. *AFOSR*-supported investigation in which spherical pellets made of various metals are fired into semi-infinite targets of the same material as the pellets.

An Experimental Investigation of the Internal Friction of Thin Platinum Alloy Wires at Low Frequencies. J. Kestin and J. M. Moszynski. *Brown U. Div. Eng. TR 11 (AFOSR TN 58-752) [AD 201516]*, July, 1958. 30 pp.

Differentiation of the Various Electrode Mechanisms by Measurement of the Transition Time at Constant Current in Unstirred Solutions. L. E. Gierst. (*Z. Elektrochem.*, No. 59, 1955, pp. 784–787.) *Gt. Brit., RAE Lib. Transl. 755*, July, 1958. 8 pp. 17 refs.

A Study of Space-Charge-Limited Potential Distribution in Ellipsoidal and Paraboloidal Diodes. R. P. Anand. *Ohio State U. Res. Found. (P-580) TN 6 (AFOSR TN 58-570) [AD 158-389]*, June, 1958. 121 pp. 34 refs.

Production and X-Ray Crystal Study of High-Glaze and Grey-Glaze Carbon, and Lamp Black. G. Becherer and B. Thiele. (*Exp. Tech. Phys.*, No. 4, 1956, pp. 50–62.) *Gt. Brit., RAE Lib. Transl. 751*, July, 1958. 13 pp. 15 refs.

Factors Affecting the Plasticity of Ionic Crystals. R. A. Lad, C. A. Stearns, and M. G. del Duca. *Acta Metallurgica*, Sept., 1958, pp. 610, 611.

Phenomenological Theory of Polarization Reversal in $BaTiO_3$ Single Crystals. C. F. Pulvari and Wolf Kuebler. *J. Appl. Phys.*, Sept., 1958, pp. 1, 315–1,321, 12 refs. USAF-supported research.

A Study of 468-Megacycle Tropospheric Scatter Propagation Over a 289-Mile Path. J. B. Atwood, G. B. MacKimmie, D. G. Shipley, and G. S. Wickizer. *RCA Rev.*, Sept., 1958, pp. 321–333.

Determinantal Approach to Meson-Nucleon Scattering. M. Baker. *Ann. Phys.*, July, 1958, pp. 271–305. 11 refs. AFOSR-supported investigation.

Models for Spectral Band Absorption. G. N. Plass. *OSA J.*, Oct., 1958, pp. 690–703. 14 refs. USAF-supported study.

Mobility of Gaseous Ions in Weak Electric Fields. E. A. Mason and H. W. Schamp, Jr. *Ann. Phys.*, July, 1958, pp. 233–270. 37 refs. AFOSR-supported application of Kihara's extension of the Chapman-Enskog theory of transport phenomena to obtain the second- and third-order approximations to the mobility of gaseous ions in a weak electric field as a function of temperature and field strength.

What Power Sources in Space? J. H. Huth. *Astronautics*, Oct., 1958, pp. 24, 25, 62–64. Study of some possible power sources obtainable from space, which reaches a negative conclusion as to their applicability for use by space vehicles. A discussion of self-contained chemical-nuclear power sources concludes that for short-duration power chemical energy sources are adaptable and, in some cases, solar batteries and isotope units can be used.

Power Plants

Design and Development of Engines for High-Speed Flight. E. S. Moult. (*London Graduates' Section Meeting, London, Mar. 15, 1958.*) *Chartered Mech. Engr.*, Oct., 1958, pp. 366–378. Discussion of the design and development processes for turbojet, ram-jet, rocket, and mixed propulsion systems.

Recherches Américaines en Matière de Propulsion d'Engins. J. Cornillon. *Docaéro*, July, 1958, pp. 21–34. In French. Survey of the development of propulsion systems in the USA, including chemical and nuclear systems, as well as those using solar energy.

Zur Strahlungsphysik der Photonen-Strahlantriebe und Waffenstrahlen. Eugen Sänger. *Forschungsinst. Phys. Strahlantriebe Mitteil. 10*, June, 1957. 173 pp. In German. Analysis of the fundamental concepts of photon rocket propulsion, including a schematic representation of the development of propulsion systems from early aviation to space travel, discussion of technical trends and limitations, radiation phenomena covering the theory of continuous radiation, the effect of photon radiation on earth's atmosphere and on solid bodies, basic problems of field-quanta emission, and possible military applications.

Missile Auxiliary Power Systems. E. I. Brown and R. A. McFarland. *Western Av.*, July, 1958, pp. 8–11. Survey of various power sources for missile equipment, and presentation of a brief comparative analysis of each.

Jet & Turbine

Samolet An-10—Silovaia Ustanovka. R. Korol' and M. Dubovik. *Grashdanskaia Aviatsiia*, Aug., 1958, pp. 14–16. In Russian. Description of the design, operation, and installation of power plants for the An-10 aircraft.

Method for Determining the Need to Rework or Replace Compressor Rotor Blades Damaged by Foreign Objects. Albert Kaufman. *U.S., NACA TN 4324*, Sept., 1958. 25 pp. Study includes the effects of the location and depth of damage, the material fatigue strength and notch sensitivity, and the maximum vibratory stress level of the blade in engine operation. The amount of strength restored by reworking the damaged area is also investigated.

Effect of Chord Size on Weight and Cooling Characteristics of Air-Cooled Turbine Blades. J. B. Esgar, E. F. Schum, and A. N. Curren. *U.S., NACA Rep. 1354*, 1958. 13 pp. 11 refs. Supt. of Doc., Wash., $0.20.

Performance and Reliability of Gas Turbine Combustion Chambers. I, II. J. S. Clarke and H. E. Lardage. *Can. Aircraft Ind.*, Aug.; Sept., 1958, pp. 20–25; 22–26. Discussion of the performance requirements and problems of high metal temperature, its control, and the effect of its variations. The factors affecting mechanical reliability in gas turbine combustion chambers are also discussed. Test results and the influence of manufacturing methods on life are described.

Ideal Performance of Valved-Combustors and Applicability to Several Engine Types. A. W. Goldstein, J. F. Klapproth, and M. J. Hartmann. (*ASME Annual Meeting, New York, Dec. 1–6, 1957, Paper 57-A-102.*) *ASME Trans.*, July, 1958, pp. 1,027–1,036. 13 refs. Estimation of pressure rise and flow capacity of valved combustors, and calculation of engine power and efficiency using valved-combustor characteristics for stationary power turbines and for turbojet and ram-jet engines. Results are compared with those from similar engines using unvalved combustors.

JT12 Design Geared to Permit Early Production Date. R. I. Stanfield. *Av. Week*, Oct. 20,

1958, pp. 56, 57, 59–63 (ff.). Description of the design, production, and performance characteristics of the JT12 power plant.

Powerplant Design Considerations for VTOL Jet Transports. M. J. Saari. *CAI-IAS Joint Meeting, Ottawa, Oct. 7, 8, 1958, Preprint 853.* 39 pp. Members, $0.35; nonmembers, $0.75. Study made in order to establish overall powerplant requirements, to define desirable engine characteristics for VTOL application, and to indicate practical approaches toward improvement of engine specific weight through component design leading to better airplane performance.

A Simple Method of Estimating the Reynolds Number Effects on Aircraft Gas-Turbine Engines Operating at High Altitudes. R. W. Pinnes. (*ASME Annual Meeting, New York, Dec. 1–6, 1957, Paper 57–A–157.*) *ASME Trans.*, Aug., 1958, pp. 1,264–1,272. Presentation of a method for estimating altitude correction factors for the Reynolds Number effects in both turbojet and turboprop engines.

Turbo-Prop Testing; Evolution of the T-Bench for Dart Overhaul Bases. C. E. Harrison. *RAeS J.*, Oct., 1958, pp. 735–745. Discussion on the history of propeller-turbine testing at Rolls-Royce. The reasons underlying the introduction of torque reaction testing and the experience and information accumulated in 2,250 hours running is given.

Gasdynamische Mischungsvorgänge, Schuberhöhung durch Strahlbeimischung. O. Lutz. (*WGL Jahrbuch*, 1957, Reprint.) *DFL Inst. Strahltriebwerke Bericht No. 86*, 1957. 7 pp. In German. Extension of previously obtained results to the study of thrust augmentation by means of jet injection, including graphic numeric representation of gas dynamic mixing.

Vibration Survey of Four Representative Types of Air-Cooled Turbine Blades. H. F. Calvert and G. T. Smith. *U.S., NACA TN 4100*, July, 1958. 22 pp. Determination of vibrational characteristics, frequencies, and stresses for turbine blades both with and without cooling.

Ram-Jet & Pulse-Jet

Ramjets. B. T. Morris. *Astronautics*, Nov., 1958, pp. 60, 61, 140, 142. Discussion of the application of ram-jet propulsion systems and survey of advances made in this field.

Reciprocating

Ionization Current in Spark-Ignition Engines. Kazuo Iinuma. *Hosei U. Tech. Coll. Rep. 3*, Aug., 1958. 24 pp. In Japanese, with summary in English.

Rocket

Raketnye Dvigateli. II—Kharakteristiki Raketnykh Dvigatelei. N. G. Smirnov. *Vestnik Vozdushnogo Flota*, July, 1958, pp. 47–55. In Russian. Discussion covering the design and operating characteristics of rocket power plants, including fuel consumption and the effect of altitude and velocity.

Screaming Tendency of the Gaseous-Hydrogen–Liquid-Oxygen Propellant Combination. Louis Baker, Jr., and F. W. Steffen. *U.S., NACA RM E58E09*, Sept. 30, 1958. 24 pp. Exploratory study of screaming made in 200-lb. thrust rocket engines. Four injector classes, a total of 12 different configurations, were tested in chamber lengths from 3 to 24 in. over the usable mixture-ratio range.

Vernier Engines. Robert McLarren. *Aircraft & Missiles Mfg.*, Oct., 1958, pp. 21–23. Description of the Vernier engines to control the attitude of the Atlas ICBM.

Solid Rockets. I. E. Tuhy. *Astronautics*, Nov., 1958, pp. 52, 53, 90. Discussion of the use and advantages of solid rocket propellants. Properties of some promising materials are evaluated.

Solids Give Liquids a Boost. Jerome Salzman. (*ARS 12th Annual Meeting, New York, Dec. 2–5, 1957.*) *Astronautics*, Oct., 1958, pp. 30, 31, 78. Discussion of a compact, simple, solid propellant gas generator that offers an alternative to high-pressure bottles or liquid propellant rocket motors.

Liquid Rockets. Y. C. Lee. *Astronautics*, Nov., 1958, pp. 50, 51, 134. Discussion of the characteristics and advantages of liquid rocket propulsion systems.

Liquid Rockets Best for Low Cost Drone Propulsion. D. W. Childs. *Space/Aeronautics*, Oct., 1958, pp. 48–57.

Effect of Fuel Drop Size and Injector Configuration on Screaming in a 200-Pound-Thrust Rocket Engine Using Liquid Oxygen and Heptane. Ch. E. Feiler. *U.S., NACA RM E58A20a*, June 11, 1958. 27 pp. 10 refs.

Combustor Performance with Various Hydrogen-Oxygen Injection Methods in a 200-Pound-Thrust Rocket Engine. M. F. Heidmann and Louis Baker, Jr. *U.S., NACA RM E58E21*, Sept. 30, 1958. 45 pp. Determination of the characteristic velocity as a function of mixture ratio in a nominal 200-lb. thrust variable-length rocket engine.

Testing Giant Rocket Engines. D. M. Tenenbaum and W. Sprattling, Jr. (*ARS Semi-Annual Meeting, Los Angeles, June 9–12, 1958.*) *Astronautics*, July, 1958, pp. 28, 29, 44–46. Description of rocket power-plant testing facilities.

Production

Flexibility Helps Build IRBM Engines. Craig Lewis. *Av. Week*, Oct. 6, 1958, pp. 60, 61, 63–69 (ff.). Description of production methods for the rocket engines used in the Thor and Jupiter missiles. The advantages of simplicity and flexibility in the production process are discussed.

Building the Jupiter-C. M. C. Duke. *Ordnance*, Sept.-Oct., 1958. pp. 330–333.

Rotodyne Rotor-Blade. I—Heat-Treatment and Machining Operations on the Main Spar. *Aircraft Prod.*, Nov., 1958, pp. 437–442.

Building the Viscount 810 Series. P. D. Imlach. *Aircraft* (Canada), Sept., 1958, pp. 26, 27, 29, 76.

Fertigungsverfahren beim Bau des Flugzeuges Dornier Do 27. O. Pönitzsch. *Luftfahrttechnik*, Sept. 15, 1958, pp. 263–272. In German. Description of manufacturing methods for the construction of the Dornier Do 27 aircraft.

Metalworking

Why and Where to Use Centrifugal Castings. II–Nonferrous Castings. J. L. Everhart. *Materials in Des. Eng.*, Sept., 1958, pp. 93–95.

High Strength Castings for High Speed Rotating Parts. J. C. Buck and D. V. Lippenberger. *Space/Aeronautics*, Nov., 1958, pp. 78–84.

Try Investment Castings. S. P. Kaprielyan. *Aircraft & Missiles Mfg.*, Nov., 1958, pp. 44–48. Description of a typical investment casting sequence; its advantages are discussed.

The Mechanical Requirements of Castings in Engineering. Appendix A—**Stress Systems Caused Through Diffusion in Materials.** Appendix B—**Transition Stresses in an Aluminum Barrel of Great Length Partially Shrunk on a Steel Barrel of Great Length.** G. Broesma. *Israel Inst. Tech., Haifa, Foundry Symposium, May 6, 1958, Paper.* 49 pp. 11 refs.

Precision Forgings Minimize Machining. A. G. Jones. *Tool Engr.*, Sept., 1958, pp. 95–97.

Close Tolerance and Other Special Forgings. W. Morgan. *CAI-IAS Joint Meeting, Ottawa, Oct. 7, 8, 1958, Preprint 856.* 6 pp. Members, $0.35; nonmembers, $0.75. Discussion of problems associated with the production of close tolerance and other special forgings, with particular reference to the dimensional limitations and design restrictions imposed.

Mace Wing-Forging Design; Precision-Forged Contour on Two-Piece 7075-T6 Wing Member Reduces Fabrication Costs. S. J. Snyder. *Aircraft & Missiles Mfg.*, Nov., 1958, pp. 18–20.

Lower Costs with No-Draft Forgings. Homer Harvey. *Materials in Des. Eng.*, Aug., 1958, pp. 94, 95.

Power-Roll Forming: Machining Without Chips. J. N. Heater. *Tool Engr.*, Oct., 1958, pp. 99–102. Discussion of the characteristics of flow forming or power spinning, and applications of the process to shaping hemispheres and nozzle-shaped contours.

Recent Heat Treatment Furnace Installations; Annual Survey of Developments. *Metallurgia*, June, 1958, pp. 283–302.

Stress Relieving of Stainless Steels and the Associated Metallurgy. R. A. Huseby. *Welding J. Res. Suppl.*, July, 1958, pp. 304-s–315-s. 19 refs.

Automatic Profile-Milling; New Machine for Two-Dimensional 360-deg. Contour Machining. *Aircraft Prod.*, Nov., 1958, pp. 416–419.

Automatic Profiling Systems for Machine Tools. R. Lawson. *Soc. Instr. Tech. Trans.*, June, 1958, pp. 45–55. Comparison of various types of profiling equipment in terms of accuracy, speed of operation, and cost.

Grinding Helical Gears; Development of the Orcutt Internal Grinding-Machine. H. J. Pearson. *Aircraft Prod.*, Oct., 1958, pp. 380–393.

Flap-Track Machining; Machine-Tool Conversion to Accommodate Large High-Tensile Steel Parts. K. Teale. *Aircraft Prod.*, Oct., 1958, pp. 412–414.

Ultrahigh Speed Machining; Solution to Producibility Problems. R. L. Vaughn. *Tool Engr.*, Oct., 1958, pp. 71–76. Discussion of the machining variables, reasons for metal failure, plastic deformation; the potentialities of ultrahigh-speed machining and explosive forming as applied to the new high-temperature metals are also discussed.

Variable-Angle Routing. *Aircraft Prod.*, Oct., 1958, pp. 394–398. Description of preset and continuously-variable machines for variable-angle routing.

Ultrasonic Welding Comes of Age. J. B. Jones and W. C. Potthoff. *Tool Engr.*, Sept., 1958, pp. 90–94. Discussion of applications, equipment, tool tip design, and strength data.

The Effect of Welding Speed on Strength of 6061-T4 Aluminum Joints. W. L. Burch. (*AWS Annual Spring Meeting, St. Louis, Apr. 14–18, 1958.*) *Welding J. Res. Suppl.*, Aug., 1958, pp. 361-s–367-s.

Flash-Welding René 41. J. P. Kushnerick. *Aircraft & Missiles Mfg.*, Nov., 1958, pp. 34, 35.

Welding of Molybdenum-Alloy Sheet. K. M. Kulju and W. H. Kearns. *Welding J. Res. Suppl.*, Oct., 1958, pp. 440-s–444-s. Description of the equipment and the arc-welding procedures used, and presentation of bend and tensile-test data for weldments in Mo-Ti sheet.

Residual Stresses in Welded Titanium Plates. E. F. Nippes and W. F. Savage. *Welding J. Res. Suppl.*, Oct., 1958, pp. 433-s–439-s. Investigation on the effects of plate dimensions, preheat, and cold treatment on residual weld factors.

Spawanie Tytanu i Jego Stopów. Julian Kieroński. *Tech. Lotnicza*, July-Aug., 1958, pp. 108–112. In Polish. Survey covering welding methods for titanium and its alloys.

The Control of Porosity in High-Nickel-Alloy Welds. G. R. Pease, R. E. Brien, and P. E. Legrand. (*AWS Annual Spring Meeting, St. Louis, Apr. 14–18, 1958.*) *Welding J. Res. Suppl.*, Aug., 1958, pp. 354-s–360-s. 17 refs.

Fundamentals of Brazing for Elevated-Temperature Service. M. D. Bellware. (*AWS Annual Spring Meeting, St. Louis, Apr. 14–18, 1958.*) *Welding J.*, July, 1958, pp. 683–691.

High-Temperature Brazing. J. V. Long and G. D. Cremer. *Aircraft & Missiles Mfg.*, Nov., 1958, pp. 13–17. Discussion on the use of brazing for fast quality production of aircraft and missile structures; its advantages are described.

Brazing Honeycomb Sandwich. F. J. Filippi. *Tool Engr.*, Sept., 1958. pp. 98–104.

Production Engineering

Automatic Inspection; Ministry of Supply Three-Dimensional Tape-Controlled System. *Aircraft Prod.*, Oct., 1958, pp. 406–409. Application of a tape-programmed stylus, responsive in three-dimensions, to the inspection of aircraft parts. The machine is controlled to follow a path which is the true nominal shape of the component in relation to the measuring head stylus.

Nondestructive Tests and Quality Control. R. P. Frohmberg. *Astronautics*, July, 1958, pp. 32, 33, 58, 59. Discussion of the role of nondestructive testing in assuring component reliability.

Non-Destructive Testing. III—Use of Dye and Fluorescent Penetrants: Auxiliary Equipment for Local Examination. *Aircraft Prod.*, Nov., 1958, pp. 420–431.

Tooling

Tool Engineering for the Space Age. T. W. Black. *Tool Engr.*, Sept., 1958, pp. 73–82. Survey of some of the new tooling and production problems encountered with the introduction of new high-temperature materials, close tolerances, and short lead times.

Tooling the Snark. A. S. Turner. *Tool Engr.*, Oct., 1958, pp. 91–93. Discussion of tooling requirements to produce guidance system components to exacting requirements.

Propellers

Propellers—A Vanishing Race. J. P. Andes. *Res. Trends* (*Cornell Aero. Lab.*), Spring, 1958, pp. 5–7. Discussion of the type of data needed for propeller design; details of the CAL dynamometer and some brief results of dynamometer tests on air induction models are included.

Research, Research Facilities

Environmental Simulation—Its Meaning and Value in System Testing. C. A. Mills. *CAI-IAS Joint Meeting, Ottawa, Oct. 7, 8, 1958, Preprint 848.* 15 pp. Members, $0.65; nonmembers, $1.00. Survey of methods for testing aircraft equipment. Various types of environment are illustrated.

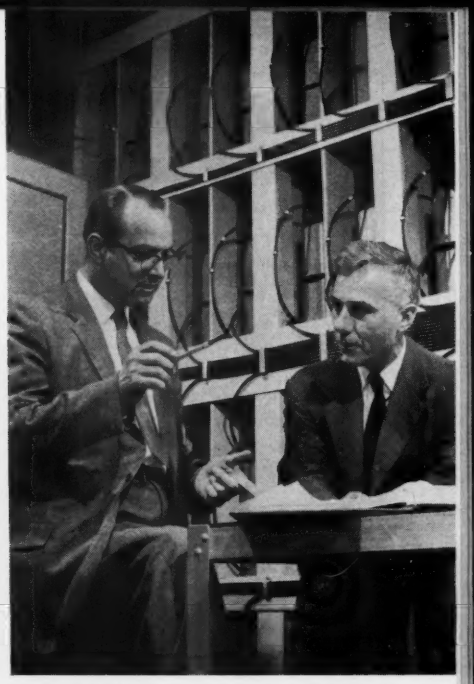
R.A.E. Facilities for Simulating Flight Environmental Conditions of Airborne Equipment. E. A. Timby. *Gt. Brit., RAE TN Mech. Eng.262*, May, 1958. 18 pp.

Supporting Research and Ballistic Missiles. L. G. Dunn. *Astronautics*, July, 1958, pp. 24, 25, 80–83. Discussion of basic research programs on fundamental physical constants, radio propagation studies, and analytical and experimental work on re-entry problems that are necessary for the long-range missile program.

Missile Reliability. J. D. Prock. *Ordnance*, Sept.-Oct., 1958, pp. 336–338. Presentation of a method for applying reliability study techniques to missile system development.

Is it Reliable. *Res. Rev.*, July, 1958, pp. 15–20. Discussion of such basic questions as the measurement of reliability, sources of unreliability, failure occurrence, and methods for improving reliability.

Explosion Hazards in Test Plant: Avoidance of Dangerous Conditions. Appendix I—Explo-



(right) Part of giant capacitor bank used to fire "hotshot" tunnel. Bank is capable of 5 million kilowatt jolt.

(above) Lockheed's "hotshot" tunnel – only one in private industry.

(right) Research and Development facilities in the Stanford Industrial Park at Palo Alto, California, provide the latest in technical equipment.

EXPANDING THE FRONTIERS OF SPACE TECHNOLOGY

Lockheed capabilities in thermodynamics and gas dynamics are unsurpassed in private industry. Basic work is being performed on problems relating to missiles and spacecraft under simulated conditions of upper atmosphere and outer space. Studies include: boundary layer flow and heat transfer; cooling and insulation; thermodynamic instrumentation for flight test; design of rocket motor controls and nozzle structures; re-entry thermal protection; materials specification; and thermal environments of electronic, mechanical and hydraulic equipment. Also under study are new methods and improved techniques of thin film thermometry, measurements of dissociation and combination of nitric oxide and high-speed shock wave flows.

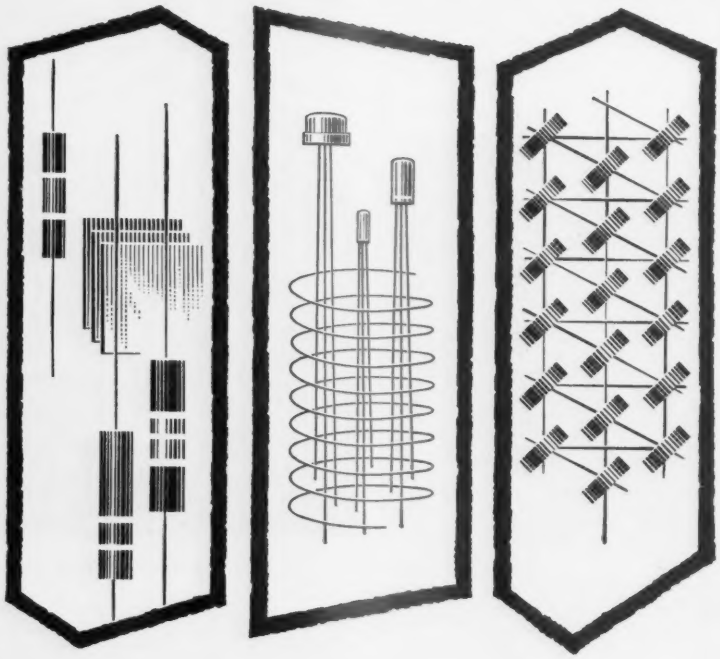
Equipment includes the fastest wind tunnel in industry, fired by 20 million kilowatts; a hydromagnetic tube which produces velocities of over Mach 250 and temperatures approaching 500,000°K; a "hotshot" tunnel for shock wave, gas and heat studies, capable of velocities of 16,500 mph and temperatures above 12,000°F; and a ballistic range on which projectiles are fired at speeds up to 20,000 ft/sec.

Scientists and engineers of outstanding talent and inquiring mind are invited to join us in the nation's most interesting and challenging basic research programs. Write: Research and Development Staff, Dept. A-11, 962 W. El Camino Real, Sunnyvale, California, or 7701 Woodley Ave., Van Nuys, California. For the convenience of those living in the East and Midwest, offices are maintained at Suite 745, 405 Lexington Ave., New York 17, New York, and Suite 300, 840 No. Michigan Ave., Chicago 11, Illinois.

"The organization that contributed most in the past year to the advancement of the art of missiles and astronautics." NATIONAL MISSILE INDUSTRY CONFERENCE AWARD

Lockheed / MISSILE SYSTEMS DIVISION / SUNNYVALE, PALO ALTO, VAN NUYS, SANTA CRUZ, SANTA MARIA, CALIFORNIA CAPE CANAVERAL, FLORIDA ALAMOGORDO, NEW MEXICO

XUM



VARIED
ENGINEERING ASSIGNMENTS
STIMULATE INTEREST ON
RCA PROJECT BMEWS

Positions with RCA's project for the new Ballistic Missile Early Warning System involve a broad range of duties. BMEWS problems demand new, adventurous approaches. Your headquarters will be in New Jersey at a location suburban to Philadelphia. You'll have the opportunity to demonstrate the feasibility of your engineering planning under actual environmental conditions in the Far North. Additional compensation for Far North trips. BMEWS' challenge requires experience in: Heavy Ground Radar Systems, Digital Computer Systems, Communications Systems, Data Handling.

Broad and liberal RCA benefits program to build security for you and your family • Work with the very latest in facilities and equipment • Every opportunity for progress in an RCA career.

TO ARRANGE CONFIDENTIAL INTERVIEW

Please send complete resume to:

Mr. Robert Vincent
RCA, Dept. BM-6A
1809 Bannard Street, Riverton, N.J.

EQUAL TOP For All Qualified Applicants OPPORTUNITY

RCA ® **RADIO CORPORATION of AMERICA**

sion and Detonation—Some Experimental Data. Appendix II—Inhibition by Water Spray and Mist. Appendix III—The Development of a Water-Wetted Flame Trap. Appendix IV—Pilot Torch System for Eliminating Unburnt Fuel by "After-Burning." R. H. Biggs and R. D. Swift. *Gt. Brit., NGTE Rep. R.225*, June, 1958. 60 pp. 14 refs. Discussion of two methods for preventing explosive conditions in power plant cells: (a) the inhibition or reduction to safe proportions of any combustible mixture which may enter the exhaust duct, and (b) the prevention of flame entering the exhaust duct even if a violent explosion should occur in the test cell and cooling system.

Beschreibung eines Schleuderprüfstandes für Beschleunigungen bis 15 g. E. Lübeck. *DFL Inst. Luftfahrzeugf., Bericht No. 94*, May 5, 1958. 18 pp. In German. Description of a centrifuge test rig for accelerations up to 15 *g* used for testing aircraft instruments. Measurements include rotational speed, radius of rotation, and acceleration.

The Ordnance Corps Envanal Program. H. M. Bunch. *CAI-IAS Joint Meeting, Ottawa, Oct. 7, 8, 1958, Preprint 849.* 7 pp. Members, $0.35; nonmembers, $0.75. Discussion of an approach to develop a valid and practical method of recording data reflecting the performance of ordnance equipment, and for comparative presentation of such data so as to indicate performance limitations under various world-wide environmental conditions.

Note on a Laboratory Apparatus to Study the High Speed Impact Between a Liquid Drop and a Surface. D. C. Jenkins, J. D. Booker, and J. W. Sweed. *Gt. Brit., RAE TN Mech. Eng. 256*, Feb., 1958. 23 pp.

Flight Testing

Bancs Volants pour Essais Turboréacteurs. H. Borsdorff and A. Desmazes. *Tech. & Sci. Aéronautiques*, Feb., 1958, pp. 25–32. In French. Historical development of the flying test benches for testing turbojet engines, and description of the test program including instruments and equipment used.

Wind Tunnels

High Speed Wind Tunnel. *Shorts Quart. Rev.*, Sept., 1958, pp. 13–16. Description of the Shorts $2^1/_2 \times 7^1/_2$ wind tunnel capable of speeds up to Mach Number 1.2, in which the power is provided by three Rolls-Royce Nene jet engines.

New Engine Test Plant at Derby. *The Aeroplane*, Oct. 3, 1958, pp. 522, 523, 526. (Also in *Flight*, Oct. 3, 1958, pp. 551–554, 558.) Design and operation of the Rolls-Royce high-altitude test plant for advanced gas turbines.

Souffleries Intermittentes à Trompe d'Induction par Eau Chaude. O. Frenzl. *Docaéro*, July, 1958, pp. 3–14. 11 refs. In French. Description of the design and operating principles of intermittent wind tunnels with hot-water injectors.

Emploi de la Strioscopie Interférentielle en Aérodynamique. M. Philbert. *La Recherche Aéronautique*, July-Aug., 1958, pp. 19–27. In French. Description of a flow visualization method using the Wollaston biprism and presentation of quantitative results obtained by ONERA.

Shock Wave Photography Improved. H. E. Edgerton. *Ind. Labs.*, July, 1958, pp. 6–8. Description of a new method for shock wave recording in daylight; its advantages are discussed.

Cylindrical Shock Waves from Exploding Wires. F. D. Bennett. *Phys. Fluids*, July-Aug., 1958, pp. 347–352. 11 refs. Description of a simple technique for rendering visible the shock wave formed by an exploding wire after the shock has been separated from the luminous contact surface.

Propulsion Wind Tunnel Digital Pressure System. R. W. Kaisner. (*NATO AGARD Wind-Tunnel & Model-Testing Panel, London, Mar. 24–28, 1958.*) *NATO AGARD Rep. 168*, Mar., 1958. 26 pp.

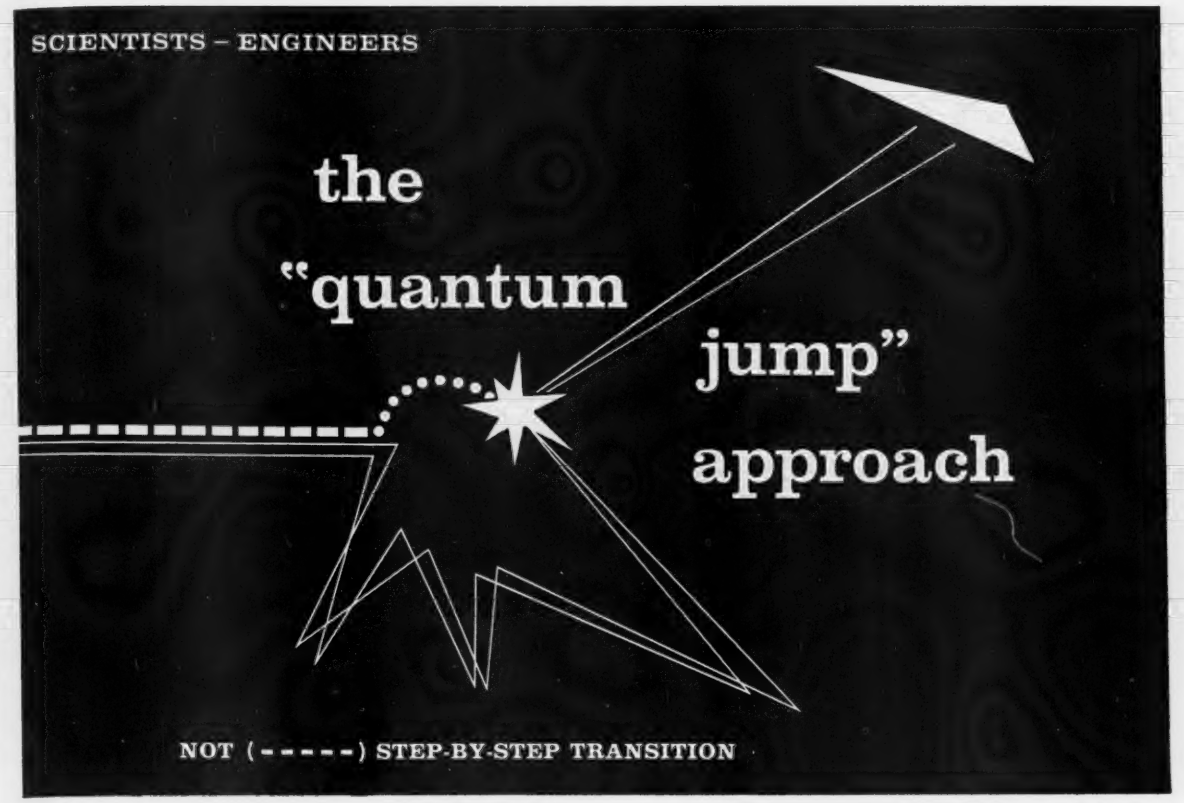
Development of Pressure Measuring Devices for a Blow-Down Wind Tunnel at the D.V.L. A. Heyser. (*NATO AGARD Wind-Tunnel & Model-Testing Panel, London, Mar. 24–28, 1958.*) *NATO AGARD Rep. 165*, Mar., 1958. 25 pp.

A Problem in Measurement. W. E. Smith. *Res. Trends* (*Cornell Aero. Lab.*), Spring, 1958, pp. 1–4. Discussion of methods for making flow, pressure, force, heat-transfer, and radiative measurements in a shock tube.

Den Hypersoniske Sjokk-Tunnelen. Torstein Fanneløp. *Tek. Tidskrift*. Sept. 23, 1958, pp. 869–875. 10 refs. In Swedish. Survey of the basic theory and derivation of design parameters for hypersonic shock tunnels.

Rotating Wing Aircraft, Helicopters

Features of the Amphibious Vertol Model 44 Helicopter. N. C. Taylor. *AHS J.*, Oct., 1958 pp. 50–54.



How Republic's Engineers & Scientists Attack Today's Missile, Aircraft and Space Problems

There's something in the environment at Republic Aviation that fires the imagination and sharpens the logical faculties.

You find it, at its quintessence, within the research groups, whose members have recently come up with a feasible design for a "Magnetic Pinch Plasma Engine" to operate in space. *A design utilizing a novel application of basic knowledge in the field of magneto-hydrodynamics.*

The same spirit of bold inquiry, of looking beyond the immediate, conventional solution of a problem for new and better answers, permeates the entire professional staff. You'll find it in development engineers working on new missiles for new missions . . in experimental engineers studying the behavior of a prototype aircraft. You'll find it in the metallurgical and electronics labs.

THE RESULT – "quantum-jump" advances in many technologies vital to the conquest of upper atmosphere and space flight.

Engineers and Scientists who share Republic's views on Creative Problem-Solving are invited to discuss opportunities now open in the following areas:

THERMO, AERODYNAMICS

Theoretical Gasdynamics • Hyper-Velocity Studies • Astronautics Precision Trajectories • Airplane/Missile Performance • Air Load and Aeroelasticity • Stability and Controls • Flutter & Vibration • Vehicle Dynamics & System Designs • High Altitude Atmosphere Physics • Advanced Propulsion • Engineer Performance • Re-entry Heat Transfer • Supersonic/Hypersonic Wind Tunnels • Shock Tunnel • Plasma Tunnel • Magneto-Hydrodynamics • Ground Control Equipment

ELECTRONICS

Inertial Guidance • Inertial Navigation • Digital Computer Development • Radar Design • Systems Engineering • Telemetry-SSB Technique • Information Theory • Doppler Radar • Countermeasures • Radio Altimeters • Radome & Antenna Design • Microwave Circuitry & Components • Receiver & Transmitter Design • Airborne Navigational Systems • Missile Checkout Systems • Missile Arming & Fusing • Jamming & Anti-Jamming • Miniaturization-Transistorization • Ranging Systems • Propagation Studies • Ground Support Equipment

REPUBLIC AVIATION is investing $35,000,000 in bold new R & D Program designed to arrive at Major Breakthroughs inTransition from Aeronautics to Astronautics.

Send resume in complete confidence to:
Mr. George R. Hickman, Engineering Employment Manager

REPUBLIC AVIATION
Farmingdale, Long Island, New York

(*Continued from page 19*)

Hampton Roads Section

"Cape" Facilities Described

Ray Shupe, Manager of Firing and Timing Engineering, R.C.A., described test facilities at the Air Force Missile Center, Cape Canaveral, Fla., in a talk sponsored jointly with the ASME and the Engineer's Club.

The operational framework there was discussed, and slides illustrated tracking facilities at range stations. Films of successful and semisuccessful missile launchings were shown. Mr. Shupe commented that missile tests which appeared to be failures often yielded valuable information before and during the failure.

JOHN M. EGGLESTON, *Secretary*

Indianapolis Section

Airplane Crash Survival

"Airplane Crash Survival Research" was the subject of an October talk by **Irving Pinkel.** Films of C-119 ground crashes with reciprocating engines, with J-47 jet engines mounted in pods beneath the wings, and with turboprop installations, were shown. Additional films of F-84 jet crashes with and without the water ingestion system showed the protection given with the system. Other experiments depicted why some crashes in aircraft are serious to personnel, and others are mild in relation to injuries sustained.

WILLIAM R. HANEY, JR., *Secretary*

Kansas City Section

Convair 880 Discussed

"Maintenance Aspects of the Convair 880" were discussed by **Gordon A. Wolcott,** Domestic Sales Manager, Convair, San Diego. Introduced by R. W. Rummel, Vice-President—Engineering, T.W.A., Mr. Wolcott said that structural design of the Convair 880 was predicated upon an anticipated nonobsolescent life span of approximately 15 years in the type of commercial service for which it was designed. Little or no structural repair or replacement as a result of fatigue should be required during this time.

C. L. Edwards, *Secretary*

Los Angeles Section

Huth, Schmued, Betchov Speak

Dr. John H. Huth, Senior Staff Member, Aeronautics Department, The RAND Corp., spoke at the October 14 Specialist Meeting on **"Characteristics of Electrical Energy Sources for Space Applications and Their Effect on Vehicle Performance."** He placed special emphasis on current limitations and the potential applicability of solar, chemical, and nuclear energy sources to space vehicles.

On October 14, **Edgar Schmued,** Consultant, formerly of Northrop Aircraft, spoke at a dinner meeting on **"Technical Management—From Airplane to Space Vehicles."** He traces the growth of technology since World War II, observing that insatiable demand for new and improved scientific, engineering, and manufacturing concepts, coupled with more comprehensive responsibilities of the weapon system contractor—has placed a challenging burden on management. He urged return to sound design principles as the key to reliability and deplored increasing reliance on machines to do "our thinking for us." Mr. Schmued concluded that a more critical evaluation of projected programs and a stronger insistence on fundamental research were essential.

On October 28, **Dr. R. Betchov** presented a conceptual development of the fundamental sources of boundary-layer wave motion.

H. R. SAFFELL, *Secretary*

Rocky Mountain Section

Missile Electronics

"Current Trends in Guided Missile Electronics" was the topic discussed by **Dr. William Carlson,** Titan Program Division, Space Technology Laboratories, The Ramo-Wooldridge Corp., at the October meeting. Dr. Carlson explained some of the problems encountered in the current trends in guided-missile electronics, plus some of their solutions.

W. KUEHNEGGER, *Secretary*

San Antonio Section

Logistic Support Topic

Thomas D. Woods, Deputy Chief of B-58 Logistic Support Management Office, San Antonio Air Materiel Area, and **John T. Cosby,** B-58 Program Director and Manager of Customer Service, Convair, Fort Worth, spoke on **"The Air Force Logistic Support System"** at the October meeting.

Mr. Woods simplified the terminology of logistic support and explained how it evolved, how research and development started, and how funding, stock control, property accounting, and supply and maintenance tie into the system.

Mr. Cosby discussed the system in action and showed how the B-58, as the first weapon system to be completely evolved under this new concept, is primarily a USAF-contractor effort. He further illustrated how a modern weapon system is supported under this system and how important it is that maintenance be simple, but precise.

ROBERT R. PERRY, *Secretary*

Texas Section

H. Reese Ivey Heard on Modern TAC

"Modern Tactical Air Power" was discussed by **H. Reese Ivey,** Assistant Director of Operational Analysis, Tactical Air Command, at the October dinner meeting. The responsibilities and objectives of the USAF in general and of the TAC in particular were outlined. Mr. Ivey said missions have changed, with potential trouble spots now 5,000, 6,000, and 7,000 miles distant, thus the importance of reaching them rapidly has made aircraft range more of a consideration for TAC than ever before.

He also observed that TAC is determining new systems requirements to meet changing times and invited industry to present ideas. Showing slides of nuclear weapon capability, he emphasized the point concerning selective use of weapons to avoid destruction of friendly civilian areas near military targets.

Mr. Ivey also showed a film covering a complete practice alert. He said that the TAC Combat Strike Force is an effective means of keeping local brush conflicts from turning into general wars; also that, in the event of general war, TAC forces would be required.

VERNON A. LEE, *Secretary*

Washington Section

Air Show Staged With AHS; Meyer Discusses Army Mobility

While the Army depends on the USAF and the Navy for strategic mobility, it is the Army—within a battle area—that must provide tactical mobility with its own resources to place decisive force where and when needed, **Brig. Gen. Richard D. Meyer** told an overflow IAS and AHS Southeast Region audience on October 21 at Fort Belvoir, Va.

General Meyer, the Army's Deputy Chief of Transportation for Aviation, spoke on **"The Army's Air Mobility Program,"** climaxing an outstanding flight and static demonstration of aircraft at Davidson Field. This held the rapt attention of some 1,200 onlookers.

Addressing 350 dinner guests, General Meyer placed emphasis on the importance of mobility in modern warfare and then observed that the Army must provide tactical mobility with its own resources. Distinguished guests in his audience were James Pyle, Administrator, CAA; John D. Macauley, Deputy Assistant Secretary, Research and Engineering, Department of Defense; and Courtney Johnson, Deputy Assistant Secretary of the Army (Logistics).

Observing that the Army must live close to the ground, General Meyer declared, "Despite comments in the press, interservice rivalry does not extend to the aviation field. If possible, the ground soldier would like to fly with one foot on the ground for close contact with the units being supported, concealment, cover, and other reasons. It is the dream of every commander to be able to free himself from the limitations and cost in resources which have been associated with the construction of lines of communications ever since the Roman highways. In Korea, at the beginning of the war, the sole means of communications were the railroads and the footpaths. Some 3 years later, thousands of miles of 32-ft.-wide hard-surfaced supply routes had been built to support over 155 miles of front."

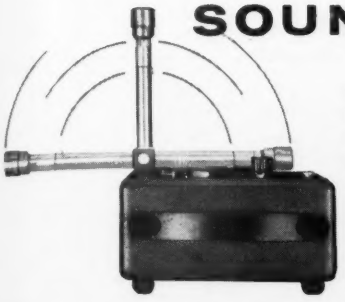
General Meyer also covered responsibilities of the Transportation Corps with respect to aviation research, development, procurement, supply and maintenance, and mechanic training. The responsibilities of the Continental Army Command in Army aviation were explained.

Speaking on research and development in aviation, General Meyer said that the

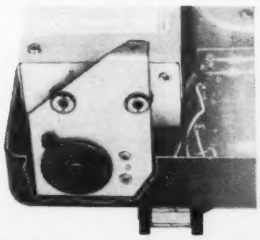
(*Continued on page 118*)

A Closer Look

at the NEW Type 1551-B SOUND-LEVEL METER



NEW "Swing-Away" Microphone Mount
New horizontal position keeps microphone away from instrument cabinet and operator's body; minimizes disturbance of sound field.



NEW Calibrated Microphone Sensitivity Adjustment
Allows quick and convenient resetting of instrument sensitivity when using special-purpose microphones.

NEW Type 1262-B A-C Power Supply $70
Mounts directly on end of Sound-Level Meter.

NEW Type 1551-P2 Leather Carrying Case
with shoulder strap **$20**
Protects instrument in transit. Cover flaps fasten together beneath case when instrument is in use.

Plus . . .

★ **Improved Signal-to-Noise Ratio.** Achieved by amplifier redesign. Extensive use of low-noise cable and shock mounts reduces microphonics caused by vibrations and air-borne sounds.

★ **Improved Stability.** Constant plate voltage is maintained on first two amplifier stages. Second stage is now a pentode, permitting greater gain and the use of more feedback around main amplifier. Output stage is now a transistor emitter follower.

★ **Improved Over-All Frequency Response.** New microphone, attenuator, and amplifier have improved frequency response . . . weighting networks fit design center of ASA characteristics more closely . . . new indicating meter has no frequency error.

★ **New Calibration Check** — built-in reference circuit eliminates need for 115-volt, 60-cycle line; permits convenient instrument calibration anywhere.

Write for the G-R Sound Bulletin for Complete Information

CONDENSED SPECIFICATIONS —

Range: From 24 to 150 db (re 0.0002 μbar)

Frequency Characteristics: Four switch positions:
A and B weighting networks are in accordance with the ASA Standard for sound-level meters.

C weighting provides flat response from 20 c to 8 kc when using the crystal microphone supplied with the instrument.

20-kc position provides a flat 20 c — 20 kc response for use with wide-range, flat-response accessories such as G-R Condenser-Microphone Systems.

Output Jack: 1 volt across 20,000 ohms when panel meter is at full scale; useful for driving spectrum analyzers, recorders, and scopes.

Meter: New quasi-rms-reading meter approaches true rms response more closely than do former types. Two damping positions: FAST, for readings in accordance with ASA standards; and SLOW, for reading the average level of rapidly fluctuating sounds.

Batteries: Two 1½-volt "D" flashlight batteries and one 67½-volt battery.

Net Weight: 7 lbs., 10 oz. with batteries.

Price: $395

GENERAL RADIO Company

275 Massachusetts Avenue, Cambridge 39, Mass., U. S. A.

NEW YORK AREA: Tel. N. Y. WOrth 4-2722, N. J. WHitney 3-3140 **CHICAGO:** Tel. Village 8-9400
PHILADELPHIA: Tel. HAncock 4-7419 **WASHINGTON, D. C.:** Tel. JUniper 5-1088
SAN FRANCISCO: Tel. WHitecliff 8-8233 **LOS ANGELES 38:** Tel. HOllywood 9-6201
In **CANADA, TORONTO:** Tel. CHerry 6-2171

GR 2-Year Warranty on every Product

WE SELL DIRECT. Our District Sales Offices are staffed by engineers especially trained to help you in the selection of instruments and measuring systems best suited to your needs. We welcome your inquiries — will help solve your problems.

big coupling for hot tailpipes

. . . high-temperature ducts and missile applications

Janitrol's new lightweight, non-torquing line of large diameter couplings provides a safe, easy to connect or disconnect, vibration-proof seal. They are simple to install, clamp together without need of a torque wrench, and assure positive alignment. Clamp latch cannot be closed unless pipe sections are correctly oriented. Total weight of the 36″ diameter clamp and two flanges is only 9.7 pounds. Clamp diameter adjusts to meet pipe production tolerances; a safety lock pin gives extra protection.

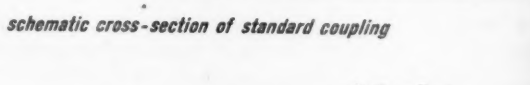
Test data: Model illustrated is tested to 15G's with tail pipe attached, and at temperatures to 900°F. Vibration requirements of MIL-E-5272A are met.

Janitrol couplings are supplied in stainless steel, with flanges of titanium, aluminum, or steel, in a wide range of sizes down to 1″ in diameter.

When you require high performance couplings for tail pipes or ductwork see your Janitrol representative.

Janitrol Aircraft Division, Surface Combustion Corporation, Columbus 4, Ohio.

schematic cross-section of standard coupling



schematic cross-section of flush coupling

JANITROL

pneumatic controls • duct couplings & supports • heat exchangers combustion equipment for aircraft, missiles, ground support

REVIEWS OF Books

. . . in the field of aeronautical engineering and space technology

ACOUSTICS

Principles and Applications of Random Noise Theory. Julius S. Bendat. New York, John Wiley & Sons, Inc., 1958. 431 pp. $11.

This book discusses principles and applications of random noise theory known to be of importance in statistical communication theory, systems analysis, automatic control, meteorology, aeronautics, radar, product testing, and many other fields. The topics covered include probability theory, random noise analysis, random processes, engineering systems, correlation functions, power spectral density functions, optimum filters, power spectra, optimum prediction and filter theory, analog computer techniques, detailed statistical error analysis for correlation measurements, advanced optimum time-variable designs, and the zero-crossing problem. In addition, a full treatment of S. O. Rice's presentation of random noise and its application to various problems is given.

The author is a Member of the Senior Staff, The Ramo-Wooldridge Corp., Los Angeles, and Lecturer in Mathematics, University of Southern California.

Studies of Noise Characteristics of the Boeing 707-120 Jet Airliner and of Large Conventional Propeller-Driven Airliners. Prepared by Bolt Beranek and Newman, Inc., for The Port of New York Authority. Cambridge, Mass., Bolt Beranek and Newman, Inc., Oct., 1958. 252 pp., diagrs., tables.

The Port of New York Authority first engaged Bolt Beranek and Newman, Inc., in 1952 to make studies of noise problems arising out of aircraft operations at New York International Airport. In 1957 the Port Authority requested that noise studies of the type that have been reported for the Comet 4 and the Caravelle Jet airliners 1, 2 be carried out on the Boeing 707-120 jet airliner as soon as it was available for test. In assigning this task, the Port Authority requested that measurements of the sound be made for a variety of altitude and power (thrust) conditions and that the effects of gross weight of the airplane and atmospheric conditions on the flight profile be ascertained. It further requested the development of data and procedures suitable for intercomparing the sound of jet aircraft with the sound of conventional propeller aircraft, on the basis of both sound level meter readings and the reaction of human beings to these sounds. The results of these requested studies are reported herein.

Contents: (1) Introduction and Terminology. (2) Information Basic to Summary Charts of Section 3 and 4. (3) Summary Data for Propeller Airliners. (4) Summary Data for Boeing 707-120 Airliner. (5) Factors Affecting the Frequency Distribution of Aircraft Sounds. (6) Noise Produced by Propeller Airliner Flights at New York International Airport. (7) Measurements and Analysis of Noise Characteristics of Boeing 707-120 Jet Aircraft Equipped with JT3C-6 Engines and FS-152 Suppressors. (8) Comparison of the Sounds from Piston and Jet Engine Aircraft by Human Listeners. (9) Perceived Noise Level. (10) Judgment Tests of the Noisiness of Sounds from Aircraft. (11) General Discussion of the Methods of Testing and Results. (12) Procedure for Combining Octave Band Levels in Decibels (DB). References.

AERODYNAMICS OF PROPULSION

Air Intake Problems in Supersonic Propulsion; Invited Papers Presented at the 11th AGARD Combustion and Propulsion Panel Meeting—Paris, December, 1956. Edited by J. Fabri. (*NATO AGARD AGARDograph 27.*) New York, Pergamon Press, 1958. 82 pp., illus., diagrs. $5.00.

Contents: Introduction, J. Fabri. (1) Rôle de la Prise d'Air Dans le Bilan Propulsif d'un Réacteur (The Role of the Air Intake in the Propulsion Balance of Rocket Engines), P. Carrière. (2) A Review of Supersonic Air Intake Problems, D. D. Wyatt. (3) Problems Related to Matching Turbojet Engine Requirements to Inlet Performances as Function of Flight Mach Number and Angle of Attack, Antonio Ferri. (4) Interprétation des Essais de Prises d'Air Supersoniques (Interpretation of Data Obtained from Supersonic Air Intake Tests), L. Viaud. Name Index. Subject Index.

AERONAUTICS, GENERAL

Aircraft Maintenance. Daniel J. Brimm and H. Edward Boggess. 3rd Ed. New York, Pitman Publishing Corp., 1958. 474 pp., illus., diagrs., tables. $5.50.

For more than 20 years, this book has been accepted as a standard text on the basic fundamentals of aircraft maintenance. It is designed as a home-study course for the student mechanic, as an aid to the instructor and student in secondary schools and CAA ground schools, and as a reference and handbook for the certificated mechanic. The complete field of maintenance and certification is covered in broad chapter classifications devoted to aircraft woodwork; aircraft metal work; aircraft fabric work and finishing; rigging, handling, maintenance; and aircraft hydraulics.

The previous edition of this work appeared in 1950.

AIRPORTS

Airline Airports; Locations Designated for Airports for Air Carrier Scheduled Operations and Related Information. U.S. Civil Aeronautics Administration. Washington, Superintendent of Documents, April, 1958. 51 pp., maps. $0.65.

The charts in this directory contain the following information for each of the 49 states and various territories: the names of airports and their locations; the longest existing runway at each with wheel loading strength, width, and length (both actual and corrected for elevation, temperature, and gradient factors); the type of airport (ultimate) recommended for each location in the 1958 National Airport Plan; and the largest aircraft authorized by the CAA for regular scheduled operations at the airport named. Listed by abbreviations are scheduled air carriers holding permanent or limited CAB Certificates of Public Convenience and Necessity authorizing them to engage in scheduled operations at the location and airport named.

Further information includes lists of code symbols for the various air carrier aircraft; domestic, territorial, and international air carriers; and U.S. air transportation system maps showing the routes of local service, trunkline, and territorial carriers and regional and district offices of the CAA.

ASTRONOMY

The Green Flash and Other Low Sun Phenomena. D. J. K. O'Connell. Photographs taken at the Vatican Observatory by C. Treusch. Amsterdam, North Holland Publishing Co., New York, Interscience Publishers, Inc., 1958. 192 pp., illus., diagrs. $6.00.

The main purpose of this work is to reproduce photographs, both in color and in black and white, of the phenomenon known usually as the "green flash" and of kindred phenomena appearing at the rising and setting of the sun (also of the moon and Venus). The book also presents the results of certain experiments carried out at the Vatican Observatory. Relevant meteorological and other data are given when available.

Although the subject of this book pertains rather to meteorological optics than to astronomy proper, the author feels that the very fact that the observational material presented in this paper could have been obtained only with astronomical equipment is sufficient reason for its appearance as an astronomical publication.

DYNAMICS

Dynamical Analogies. Harry F. Olson. 2nd Ed. Princeton, N. J., D. Van Nostrand Co., Inc., 1958. 278 pp., diagrs. $6.75.

This revised and enlarged edition of a work first published in 1943 deals with the analogies between electrical, mechanical, acoustical, and magnetic systems. It will, therefore, be of use to scientists concerned with machines and vibrating systems, and to electrical, electronic, mechanical, automotive, and acoustical engineers. By means of analogies, an unfamiliar system can be compared with one that is better known. The relations and actions are more easily visualized, the mathematics more readily applied, and the analytical solutions more readily obtained in a familiar system. The subject matter is developed in stages from the simple element through a complex arrangement of multielement systems. As an aid in the establishment of these analogies a complete theme is depicted in each illustration. The author is in charge of acoustical research for the RCA Manufacturing Co.

Contents: (1) Introduction and Definitions. (2) Elements. (3) Electrical, Mechanical Rectilineal, Mechanical Rotational, and Acoustical Systems of One Degree of Freedom. (4) Electrical, Mechanical Rectilineal, Mechanical Rotational and Acoustical Systems of Two and Three Degrees of Freedom. (5) Corrective Networks. (6) Wave Filters. (7) Transients. (8) Driving Systems. (9) Generating Systems. (10) Theorems. (11) Applications. (12) Noise and Distortion. (13) Feedback. (14) Mobility Analogy. (15) Magnetic Analogy. Index.

ELASTICITY & PLASTICITY

Elasticity and Plasticity: The Mathematical Theory of Elasticity, J. N. Goodier; **The Mathematical Theory of Plasticity,** P. G. Hodge, Jr. (*Surveys in Applied Mathematics, Vol. 1.*) New York, John Wiley & Sons, Inc., 1958. 152 pp., diagrs. $6.25.

The authors' principal aim is to draw attention to significant recent developments in the mathematical theories of elasticity and plasticity, concentrating on the modern trends in analysis. Emphasis is on contributions made by Russian authors and others whose work is not yet fully integrated into the western literature.

The authors are, respectively, Professor of Engineering Mechanics, Stanford University, and Professor of Mechanics, Illinois Institute of Technology.

ELECTRONICS

Synthesis of Linear Communication Networks, Vols. 1 & 2. Wilhelm Cauer. 2nd Ed. Edited by Wilhelm Klein and Franz M. Pelz; Translated from the German by G. E. Knausenberger and J. N. Warfield. New York, McGraw-Hill Book Co., Inc., 1958. 866 pp., diagrs., tables. $17.

This is a translation, in two combined volumes, of the classic German reference work, *Theorie der linearen Wechselstromschaltungen*, which appeared in 1941 and was designed to acquaint scientists and engineers with the fundamentals and practices of network design. It gives comprehensive coverage of the basic principles of circuit theories and provides aids for their practical design. *Volume I* contains the basic exposition of network analysis and synthesis, as well as the discussion of the image-parameter method, including as appendixes a formula collection and practical means of filter design with tables, design charts, and examples. *Volume II* is a standard reference on basic history, development, and state of the art of modern driving point and transfer-function synthesis of electrical networks.

Contents: Volume I. Introductory Chapter. (1) Statement of the Problem and Examples. (2) Circuit Analysis. (3) Two-Terminal-Pair Networks. (4) Positive-Real Functions and Positive Matrices. (5) Reactance Theorems. (6) Image Parameter Theory of the Low-Pass Reactance Filter. (7) Generalized Image-Parameter Theory. *Appendix 1:* Two-Terminal-Pair-Network Formula Collection. *Appendix 2:* Practical Filter-Design Techniques Based on the Image-Parameter Theory.

Volume II: (8) Reactance Two-Terminal-Pair Networks with Prescribed Operating Conditions. (9) Frequency Band-Separation Networks. (10) Equivalence of Reactance Networks. *Appendix 1:* Aids in Linear Algebra. *Appendix 2:* Elements in the Theory of Analytic Functions. *Appendix 3:* Solution of Some Chebyshev Extremal Problems. *Appendix 4:* Practical Filter Design Techniques Based on the Operating-Parameter Theory. *Appendix 5:* Recent Advances; Supplementary References. Index.

EXPLOSIVES

The Science of High Explosives. Melvin A. Cook. (*American Chemical Society. Monograph No. 139.*) New York, Reinhold Publishing Corp., 1958. 440 pp., illus., diagrs., tables. $22.50.

Confined to the more important problems in the physical chemistry of detonating explosives, this volume describes detonation processes and related phenomena with theoretical interpretations. It includes critical discussion and evaluation of

initiation, wave structure, propagation, the nature and rates of chemical reactions of detonations, ionization, radiations, shock and blast waves, and damage resulting from detonation. The book also presents fundamental principles and pertinent facts for technological applications including commercial blasting, demolition, shaped charges, fast particles, shock and blast wave propagation, impact loading, strength, penetration, and conditions for explosion of materials. Data and procedures for computing thermohydrodynamic properties and products of detonation, as well as modern technology of experimental explosives, are presented. The work features high-speed photographs of various types of explosives.

The author is Professor of Metallurgy and Director, Explosives Research Group, University of Utah.

FLUID MECHANICS

An Introduction to Fluid Dynamics. F. J. Bayley. New York, Interscience Publishers, Inc., 1958. 215 pp., illus., diagrs. $4.50.

Intended as a text to accompany undergraduate courses in fluid mechanics, this book presents the principles of the subject and takes the reader to the point at which he himself may begin to specialize in the practical aspects of fluid mechanics, such as detailed machine design, or in the more theoretical fields of higher hydro- and aerodynamics. The book is concerned mainly with the study of fluids in motion, but the problems of fluids at rest are dealt with in a separate chapter to illustrate the principles which arise in this special branch of fluid mechanics. To avoid the confusion between these two aspects of fluid motion, momentum and energy changes in moving fluids are considered in separate chapters. The remainder of the text deals with dimensional analysis, the effects of viscosity, losses in pipes, and flow in open channels and over immersed bodies.

The author is Lecturer in Mechanical Engineering, The University of Durham.

GAS DYNAMICS

Mathematical Aspects of Subsonic and Transonic Gas Dynamics. Lipman Bers. (*Surveys in Applied Mathematics, Vol.* 3) New York, John Wiley & Sons, Inc., 1958. 164 pp., diagrs. $7.75.

This work is concerned with a limited part of the theory of compressible fluid flow—two-dimensional steady potential flows. Mathematical methods are emphasized rather than the physical problems themselves, and the "applications" of fluid dynamics as a source of mathematical concepts are stressed. Particular attention is paid to existence and uniqueness questions for subsonic and transonic flow problems.

The author is associated with the Institute of Mathematical Sciences, New York University.

GEOPHYSICS

Advances in Geophysics, Vol. 5. Edited by H. E. Landsberg and J. Van Mieghem. New York, Academic Press, Inc., 1958. 325 pp., diagrs., tables. $10.

This volume presents, as have the preceding ones, a wide variety of topics relating to progress and current investigations in geophysical research which should be tremendously enhanced by the forthcoming evaluation of data collected during the International Geophysical Year now drawing to a close. In this connection, the lead article of this volume is of particular interest in that it details the objectives and results of previous International Years in which scientific investigation first took on a truly international flavor and materially assisted in the advance of the physical sciences.

Contents: (1) From Polar Years to IGY, N. C. Gerson. (2) Microseisms, B. Gutenberg. (3) The Size and Shape of the Earth, R. A. Hirvonen. (4) Oceanic Tides, A. T. Doodson. (5) Ultraviolet Absorption Process in the Upper Atmosphere, K. Watanabe. (6) The Physics of Cloud Modification, James E. McDonald. Author Index. Subject Index. Cumulative Title Index, Volumes I–IV. Cumulative Subject Index, Volumes I–IV.

MATERIALS

Dangerous Properties of Industrial Materials. N. Irving Sax. New York, Reinhold Publishing Corp., 1957. 1,467 pp., diagrs., tables. $22.50.

This book is an enlargement of a previous edition published in 1951 and entitled *Handbook of Dangerous Materials*. Its objectives are to present a detailed picture of the hazards which accompany the use of the materials of industry and to provide background enough to solve on-the-spot safety problems that arise in daily industrial operations. The greater portion of the text consists of the *General Chemical Section*, which has been expanded from 5,500 to 9,000 entries, and details for each compound or material: its description, formula, constants, toxicity, fire and explosion hazards, control, and storage and handling properties. A new section, by Joseph J. Fitzgerald, has been added which deals with reactor safeguards, and the text on radiation hazards in industry has been expanded. The remaining ten sections are devoted to Toxicology, Leonard Goldwater; Ventilation Control, William B. Harris; Personnel Protection and Personal Hygiene, William B. Harris; Atmospheric Pollution, William B. Harris; Radiation Hazards, John H. Harley; Industrial Fire Protection, N. Irving Sax; Storage and Handling of Hazardous Materials, N. Irving Sax; Allergic Disease in Industry, Milton S. Dunn; Shipping Regulations; and Index to Synonyms.

Effect of Surface on the Behavior of Metals; Lectures Delivered at the Institution of Metallurgists Refresher Course, 1957. London, Iliffe & Sons, Ltd.; New York, Philosophical Library, 1958. 100 pp., illus., diagrs. $10.

Contents: (1) Methods of Preparation and Examination of Surfaces, G. L. J. Bailey. (2) Influence of Surface Treatments on the Chemical Behaviour of Metals, T. P. Hoar. (3) Relationship Between Surface Condition, Friction and Wear, F. T. Barwell, (4) Influence of Surface on the Physical Properties of Metals, R. W. B. Stephens.

MATHEMATICS

Introduction to Functional Analysis. Angus E. Taylor. New York, John Wiley & Sons, Inc., 1958. 423 pp. $12.50.

While this book is principally addressed to graduate students, it is also intended to be useful to mathematicians, both pure and applied, who have need of a simple and direct presentation of the fundamentals of the theory of linear spaces and linear operators. The central theme of the book is the theory of normed linear spaces of linear operators which map one such space into another. Although the emphasis is mainly on normed linear spaces, the more general ideas of topological linear spaces are developed to some extent since an understanding of these is relevant at many places in the theory of normed linear spaces, notably in connection with the weak topologies of such spaces and their conjugate spaces. There are many illustrations and applications of the abstract concepts and methods. The author is Professor of Mathematics, University of California at Los Angeles.

Contents: (1) The Abstract Approach to Linear Problems. (2) Topologies. (3) Topological Linear Spaces. (4) General Theorems on Linear Operators. (5) Spectral Analysis of Linear Operators. (6) Spectral Analysis in Hilbert Space. (7) Integration and Linear Functionals. Bibliography. List of Special Symbols. Index.

STANFORD RESEARCH INSTITUTE

Has Responsible Professional Opportunities in the fields of

ACOUSTICS
VIBRATIONS
MECHANICS

Research Activities involve theoretical and experimental aspects of:

- Noise reduction
- Vibration generation & transmission
- Random vibrations
- Unsteady fluid flow
- Structural mechanics
- Ultrasonics

SRI

The continuing growth of activities at SRI offers excellent opportunities for qualified Mechanical Engineers and Physicists on the BS through PhD levels with at least 2 years experience (graduate work accepted) involving acoustics or mechanical vibrations.

Projects are varied and professionally challenging, offering unique opportunities to develop personal competence and broad experience.

Stimulating associations, good research facilities and responsible assignments, coupled with living and working in one of the most desirable areas of the San Francisco Bay Area, complement an atmosphere conducive to professional growth and development.

Advance Study Opportunities Available in the Area

Write to:

Professional Employment Manager
Stanford Research Institute
Menlo Park, California

Here's a good habit...

Check the "New Products Section" at the end of this issue for a complete resume of all recently announced new product developments and product literature of special interest to engineers and designers of aircraft, missiles, rockets, and spacecraft. It is easy to find — easy to scan — easy to use.

Handy postage-paid inquiry cards are included for your convenience in requesting additional information.

Make it a habit
use the
"New Products Section"
every month

AERO/SPACE ENGINEERING
2 East 64th Street, New York 21, N. Y.

CHALLENGING OPPORTUNITIES in RESEARCH and DEVELOPMENT for MECHANICAL DESIGN ENGINEERS

Mechanical Engineers experienced in mechanical design for packaging electronic equipment to meet environmental conditions.

FLUID MECHANICS ENGINEERS

Engineers of advanced standing for work in basic and applied research in field of underwater propulsion and related subjects, including cavitation, hydroelasticity, and hydrodynamic control of submerged bodies.

Opportunities for Graduate Study

Faculty Appointments for Qualified Applicants

Excellent Working and Living Conditions

Send Resume To:

ARNOLD ADDISON,
Personnel Director
The Pennsylvania State University
Ordnance Research Laboratory
P. O. Box 30
University Park, Pennsylvania

SPACE POWER AND PROPULSION SYSTEMS

programs have created responsible opportunities for engineers with significant supervisory experience in

ENGINEERING RESEARCH
DEVELOPMENT ENGINEERING
ADVANCED SYSTEMS ANALYSIS

Applicants must hold an engineering degree with a background of engineering analysis, design and planning for research programs as applied to power, control and propulsion of air and space vehicles.

For further information, please contact

Thompson Ramo Wooldridge Inc.

P.O. BOX 287
INGLEWOOD 1, CALIFORNIA

The Prediction of Ballistic Missile Trajectories from Radar Observations. I. I. Shapiro. New York, McGraw-Hill Book Co., Inc., 1958. 208 pp., diagrs., tables. $7.00.

This monograph develops methods, based on the statistical theory of parameter estimation, that can be used to determine ballistic missile trajectories. The information upon which the estimates are based is obtained from observations of the missile by monostatic radars located at one or more sites. Prime consideration is given to maximum likelihood parameter estimates. An extensive analysis of the random errors associated with predictions based on the maximum likelihood method is also given. Such an error analysis provides a good approximation to the maximum prediction accuracy obtainable for systems containing monostatic radars. Finally, there are several chapters in which the changes in the prediction methods necessary to account for the earth's rotation and the earth's oblateness are developed. With extremely slight modification, the methods developed can be used to estimate the osculating parameters of satellite orbits, although, to predict such orbits for long-time intervals after observation, more serious modification would be required.

The author is a staff member of the Lincoln Laboratory, Massachusetts Institute of Technology.

Some Aspects of Analysis and Probability: Functional Analysis, Irving Kaplansky; **A Survey of Combinatorial Analysis,** Marshall Hall, Jr.; **A Survey of Abstract Harmonic Analysis,** Edwin Hewitt; **Recent Advances in Probability Theory,** Robert Fortet. (*Surveys in Applied Mathematics, Vol. 4.*) New York, John Wiley & Sons, Inc., 1958. 243 pp. $9.00.

This four-part work is made up of survey articles which have the primary objective of accounting in a summary fashion for the state of the fields which they cover, as determined by contributing developments at various times and in many places. The chapters on functional analysis begin by reviewing the progress that has been made on the problems posed by Banach and then pass on to topics which are of high current interest and are undergoing intense development: locally convex spaces and their operators, Banach algebras, and group representations. In combinatorial analysis, emphasis is placed on three main categories: problems of enumeration, theorems of choice, and the existence and construction of designs. Harmonic analysis is approached from both its classical and its abstract sides. Finally, in the section on probability theory, priority in discussion is given to papers which are capable of applications, papers which open new areas for further research, and papers which are probably not very well known because of the language in which they are published, such as Russian, Hungarian, etc. Stochastic processes are thoroughly examined, but other topics, such as the theory of games and mathematical economics, are excluded.

MECHANICS

Dynamics and Nonlinear Mechanics: Some Recent Advances in the Dynamics of Rigid Bodies and Celestial Mechanics, by E. Leimanis; **The Theory of Oscillations,** by N. Minorsky. (*Surveys in Applied Mathematics, Vol. 2.*) New York, John Wiley & Sons, Inc., 1958. 206 pp., diagrs. $7.75.

The first part of this book surveys modern analytical progress in the treatment of classical dynamical problems which are assuming increasing importance in today's technology. The second part outlines the current state of the art in the analysis of nonlinear oscillating systems and points the way to future developments in this field, which is receiving such great emphasis in control system engineering and in other technical areas.

The authors are, respectively, Professor of Mathematics, University of British Columbia, and Professor of Physics, Stanford University.

NUCLEAR ENERGY

The Effects of Radiation on Materials; From a Colloquium Sponsored by the Office of Naval Research Jointly with The Martin Company at Johns Hopkins University in Baltimore in March, 1957. Edited by J. J. Harwood, Henry H. Hausner, J. G. Morse, and W. G. Rauch. New York, Reinhold Publishing Corp., 1958. 355 pp., illus., diagrs., tables. $10.50.

Contents: (1) Defects in Solids and Current Concepts of Radiation Effects, G. J. Dienes. (2) Experimental Approaches to Radiation Studies—Radiation Sources and Dosimetry, J. C. Wilson. (3) Radiation Effects on Physical and Metallurgical Properties of Metals and Alloys, E. S. Billington. (4) Influence of Radiation Upon Corrosion Behavior and Surface Properties of Metals and Alloys, M. Simnad. (5) Effects of Radiation on Electronic and Optical Properties of Inorganic Dielectric Materials, R. Smoluchowski. (6) Effects of Radiation on Semiconductors, H. Y. Fan and K. Lark-Horovitz. (7) Cores, Liquid Coolants and Control Rods, C. E. Weber. (8) Moderators, Shielding and Auxiliary Equipment, G. R. Hennig. (9) Experimental Techniques and Current Concepts—Organic Substances, M. Burton. (10) Effects of Radiation on Behavior and Properties of

ASI ENGINEERS & SCIENTISTS

Here is your opportunity to grow with a young, expanding subsidiary of the Ford Motor Company. Outstanding career opportunities are open in Aeronutronic's new RESEARCH CENTER, overlooking the Pacific at Newport Beach, and the facility in Glendale, California. You will have all the advantages of a stimulating mental environment, working with advanced equipment in a new facility, located where you can enjoy California living at its finest.

PhD and MS RESEARCH SPECIALISTS with 5 to 7 years' experience in heat transfer, fluid mechanics, thermodynamics, combustion and chemical kinetics, and thermoelasticity. To work on theoretical and experimental programs related to re-entry technology and advanced rocket propulsion. Specific assignments are open in re-entry body design, high temperature materials studies, boundary layer heat transfer with chemical reaction, thermal stress analysis, and high temperature thermodynamics.

PROPULSION ENGINEERS with 5 years' experience in liquid and solid rocket design and test. Familiarity with heat transfer problems in engines desirable. To work on program of wide scope in R & D of advanced concepts in rocket engine components, and for missile project work.

ADVANCED AERODYNAMIC FACILITY DESIGNER. Advanced degree desired. To supervise work in design and in instrumentation of advanced aerodynamic test facilities such as shock tubes, shock tunnels, plasma-jets, and hyper-velocity guns.

STRUCTURAL ANALYSIS SECTION SUPERVISOR with 8 to 10 years' experience, including supervision, in the missile field. Graduate degree for design and analysis required. Will be required to apply knowledge of high temperature materials and methods, thermal stress, dynamics, etc., to advanced hypersonic vehicles re-entry bodies, and space vehicles.

FLIGHT TEST & INSTRUMENTATION ENGINEERS with 5 to 10 years' experience in laboratory and flight test instrumentation techniques. Will develop techniques utilizing advanced instrumentation associated with space vehicles.

THEORETICAL AERODYNAMICIST. Advanced degree and at least 5 years' experience in high-speed aerodynamics. Knowledge of viscid and inviscid gas flows required. To work on program leading to advanced missile configurations. Work involves analysis of the re-entry of hypersonic missiles and space craft for determining optimum configuration.

DYNAMICIST. Advanced degree, applied mathematics background, and experience in missile stability analysis desirable. Work involves re-entry dynamics of advanced vehicles and dynamic analysis of space craft.

ENGINEER or PHYSICIST. With experience in the use of scientific instruments for making physical measurement. Work related to flight test and facility instrumentation. Advanced degree desired with minimum of 3 years of related experience.

Qualified applicants are invited to send resumes and inquiries to Mr. L. R. Stapel.

AERONUTRONIC SYSTEMS, INC.

a subsidiary of Ford Motor Company

2234 Air Way Bldg. 13, Glendale, Calif.
CHapman 5-6651

Polymers, A. Charlesby. (11) Radiation-Induced Graft of Copolymerization, A. J. Restaino. (12) Bibliography "Effect of Irradiation on Solids," H. Friedemann. Index.

POWER PLANTS

Aircraft Engines of the World, 1958/59. Paul H. Wilkinson. Washington, 734 15th St., Wash. 5, D.C., 1958. 320 pp., illus., diagrs., tables. $15.

The sixteenth volume in this annual series has once again been largely revised, with many new engines added and much revision of engines carried over from the previous volume. The *Gas Turbine Engines* section, comprising main aircraft power plants, has been increased to 171 pages and contains descriptions of more than 100 of the latest engines in service, including 24 that are new. Russian engines include the AM-3, NK-4, and NK-12 for commercial aircraft, and the M-205, M-209, and VK-1 for military planes. East and West Germany are represented for the first time, and there is also a new Japanese engine, the Kawasaki KAE-240. Tabulations of 98 of the latest turbojets and turboprops are included for comparison purposes, and the introduction to this section describes the latest activities of 40 engine manufacturing groups in 13 countries.

The *Specialized Gas Turbines* section, comprising 15 pages of recent turbocompressor and turboshaft power plants, includes two new engines. Also five rocket-jets for manned aircraft and one ram-jet are illustrated and described in detail. The *Reciprocating Engines* section has been increased to include 66 complete specifications. There are ten new engines, including an American turbosupercharged helicopter engine, five conventional American engines, a Czechoslovak engine built under Russian license, a West German engine, and two small Italian power plants. The introduction describing activities in this field contains an up-to-date tabulation of helicopter engines. The *Aircraft and Their Engines* section contains six completely revised tabulations, comprising particulars of 264 of the latest military and commercial aircraft in service (including Russian) which are powered by gas turbines or reciprocating engines.

In addition to these main fields of interest, Mr. Wilkinson also supplies an overall picture of the development of nuclear aircraft engines, accessories and equipment, and fuel and lubricating oil tabulations.

PRODUCTION

Kaiser Aluminum Weldor's Training Manual: Inert Gas Process. George Allen. Chicago, Kaiser Aluminum & Chemical Sales, Inc., 1958. 129 pp., illus., diagrs., tables. $1.00.

This manual presents information designed to train and qualify individuals in welding aluminum by the inert gas process. The book is divided into three main parts: Basic Theory of Aluminum Welding, Practical Exercises Training and Qualifying Weldors for TIG Welding of Aluminum, and Practical Exercises Training and Qualifying Weldors for MIG Welding of Aluminum.

ROCKETS

Solid Propellant Rockets, An Introductory Handbook. Alfred J. Zaehringer. 2nd Stage. Wyandotte, Mich., American Rocket Co., 1958. 306 pp., illus., diagrs., tables. $8.00.

The present volume is an expanded version of *Solid Propellant Rockets* which was published in 1955 and was designed to provide the engineer and scientist with a single source of reference pertaining to solid propellant rocketry. Since this book is introductory in nature, certain subjects have been treated in only a very general fashion. This is particularly true of combustion and related items where technological gains have been rather slow, and of other fields such as propellants, performance data, and rocket specifications where information is limited by security considerations. Some sections are also applicable to liquid propellant rockets and will prove useful to persons working in this latter field. The author is President, American Rocket Co.

STRESS ANALYSIS

Introduction to the Theoretical and Experimental Analysis of Stress and Strain. A. J. Durelli, E. A. Phillips, and C. H. Tsao. New York, McGraw-Hill Book Co., Inc., 1958. 498 pp., illus., diagrs., tables. $12.50.

This introduction gives an overall picture and a balanced description of the several methods used in the field of stress analysis. The theory of elasticity is presented from the general three-dimensional point of view. Although the conventional parallelepiped approach is used, references are made whenever necessary to the underlying philosophy of the rigorous theoretical development. A few elementary problems are solved with the theory of elasticity, and the Kirsch solution of the infinite plate with a circular hole is developed in detail. In addition, the text contains an extensive treatment of brittle coating properties as they relate to stress analysis. The authors are, respectively, Supervisor, Stress Analysis Section, Armour Research Foundation; Research Engineer, Standard Railway Equipment Manufacturing Co.; and Member, Technical Staff, Hughes Aircraft Co.

Contents: Part 1. Mathematical Method of Analysis. (1) Theory of Stress. (2) Theory of Strain. (3) Geometric Representation of the State of Stress and Strain at a Point. (4) Theory of Elasticity. (5) Application of Three-Dimensional Problems. (6) Two-Dimensional Problems in the Theory of Elasticity. (7) Geometric Representation of the Two-Dimensional State of Stress and Associated State of Strain at a Point. (8) Properties of Special Families of Curves. (9) Application to Two-Dimensional Problems. *Part 2. Introduction to the Use of Experimental Stress-Analysis Methods.* (10) Fundamental Concepts in Strain Measurements. (11) Statistical Methods and Their Application to Experimental Stress Analysis. (12) Dimensional Analysis. *Part 3. Grid Methods.* (13) Grid Methods. *Part 4. Brittle-Coating Methods.* (14) General Background of Brittle Coating. (15) Stresses and Strains in Brittle Coating. (16) Properties of Stresscoat. (17) Application of the Brittle-Coating Method. *Part 5. Mechanical Strain Gages.* (18) Mechanical Strain Gages. Index.

Proceedings of the Society for Experimental Stress Analysis, Vol. 15, No. 2. Edited by C. V. Mahlmann and W. M. Murray. Cambridge, Mass., The Society, 1958. 178 pp., illus., diagrs. tables. $6.00.

Contents: (1) Photoelastic Photography, J. H. Flanagan. (2) A Machine for High Temperature Fatigue Testing of Gas Turbine Buckets. J. O. Anderson and C. F. Sanborn. (3) A Simplified Method of Obtaining Principal Stress Information from Strain Gage Rosettes, P. K. Stein. (4) Some Simplifications in Rosette Analysis, W. M. Murray. (5) Residual Stresses in Cylinders, V. Weiss. (6) Further Studies of Properties of Stresscoat Under Dynamic Loading, J. W. Dally, A. J. Durelli, and V. J. Parks. (7) A Dynamic Strain Calibration Device, S. Okubo, A. J. Durelli, and J. W. Dally. (8) Experimental Solution of Stress Diffusion Problems, C. Riparbelli. (9) Structural Dynamic Tests of Propeller Blades in Vacuo, M. O. Burquest, J. E. Carpenter, and E. M. Sullivan. (10) The Transformation of Families of Data Curves to Alignment Nomograms, with Applications to Stress Data, A. S. Levens. (11) A Rapid Method of Waterproofing Bonded Wire Strain Gages, F. E. Wells. (12) Discussion of Paper Entitled: "Static and Dynamic Calibration of a Photoelastic Model Material, CR-39", G. W. Sutton. (13) Discussion of Paper Entitled: "The Concept of Strength from Goodman Diagrams," H. O. Fuchs.

Proceedings of a Panel Discussion on Thermal Stresses: (14) Introductory Remarks, B. F. Langer. (15) Thermal Stress and Thermal Stress Fatigue, L. F. Coffin, Jr. (16) Thermal Stress Problems in Practice, R. U. Blaser. (17) Design Basis for Thermal Stresses, W. E. Cooper.

✦ ✦ ✦

IAS News *(Continued from page 112)*

Army's desires are for vigor, imagination, and wisdom. He declared that the Transportation Corps intends to attract the best brains in the country to assist Army aviation and that the Army intends to continue and expand basic research efforts in the universities. He added the hope that "the outstanding scientists associated with this work will continue to think about Army problems and propose solutions."

General Meyer emphasized that the results of basic and applied research must be made available to all of industry so that a maximum benefit can be obtained from the new information, and data developed. The Army, he said, will continue to have public demonstrations of research aircraft and sponsor symposia to assist the sharing of research results by all of industry.

He stressed that air vehicles in the Army do not reach obsolescence rapidly because performance requirements do not require the maximum capabilities for speed and altitude available from the state of the art. "Consequently, more time is available for testing a design before it is produced for field use.

"Maintenance and supply of the air vehicle also is inseparably related to design. The ideal vehicle would require no maintenance. A combat air vehicle should be removed from the combat area and replaced by a fresh unit or serviced by a specialized team sent in as required. The skilled technician should be removed from the crowded combat area, leaving only combat soldiers."

The social period was sponsored by Sikorsky Aircraft, Bell Helicopter, Kaman Aircraft, Beech Aircraft, Cessna Aircraft, McDonnell Aircraft, Vertol Aircraft, Goodyear Aircraft, and Hiller Helicopters.

Beginning the flight demonstration was a fly-by of five H-21 helicopters. This was followed by a fly-by and formation landing of H-37, H-21, and H-34 helicopters.

The McDonnell Model 120 multiengine pressure jet flying crane helicopter was demonstrated. The Goodyear Inflatoplane was taken from a small package and put in flight condition. The Army Quartermaster Corps' ultra-fast-opening parachute, for escape from low-flying aerial vehicles, was demonstrated from the bed of a truck driving down the runway. The chute was actuated and opened fully in about 8/10 of a second, and the dummy used in the demonstration landed beside the runway with what appeared to be no greater force than that experienced in normal parachute operations. (For a detailed discussion of this development, see "Extending Capabilities of Escape and Aerial Delivery Systems," by Fred B. Stencel, pp. 47–52.—*Editor*)

An interesting demonstration was the first public flight of a Vertol tilt-wing research aircraft which accomplished VTOL and also—though restricted in flight to the area above the paved runway—a vertical take-off, a nearly complete conversion to level flight, and a vertical landing.

Next on the program was a demonstration of an Army-owned French Djinn cold-pressure jet helicopter. The little machine demonstrated its maneuverability and remarkable autorotation landing characteristics.

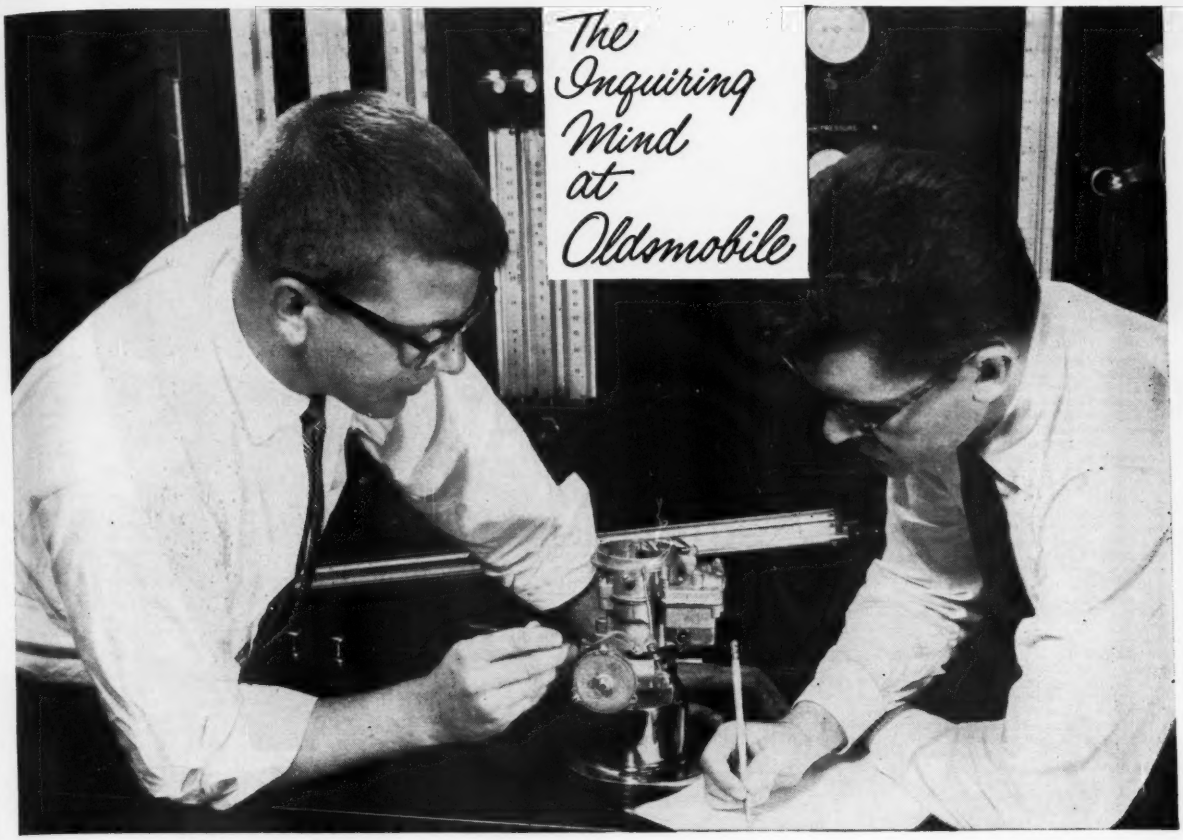
The Vertol 107 twin turbine-powered tandem rotor transport helicopter flew by the audience, then landed before the viewing stands and unloaded a full-scale mock-up of an Honest John rocket. A simulated land mine cargo was loaded on the helicopter, and a demonstration of low-altitude land mine laying behind enemy lines was presented.

Finally, a Sikorsky H-37 helicopter brought in a 75-mm. gun and Honor Guard, and the latter performed a military retreat ceremony to end the demonstrations. The vehicles flown, plus others, were then placed on static display.

QUENTIN J. GOSS, *Secretary*

Attention Members!

All members of the Institute are invited to submit material concerning their activities for publication in the "News" columns of *Aero/Space Engineering.*



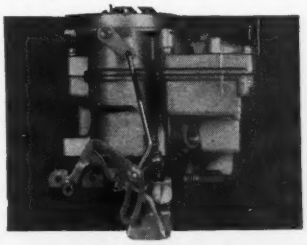
no. 6 OF A SERIES

TWO STEPS TO NEW FUEL ECONOMY

Unique Oldsmobile-developed two-stage automatic choke is a major step forward in improving automobile operating economy.

One of the important carburetor developments during the past few years was the automatic choke, a device that allows the automobile to be started in cold weather, and then keeps it running until the engine is sufficiently warmed up to sustain itself. Every automatic choke has two separate functions: 1) choking, which enriches the fuel-air mixture for starting, and 2) the idle speed control, which keeps the engine from stalling once it is started. In the past, and on all present carburetors except those used on the 1959 Oldsmobile, these two functions have operated simultaneously with the result that the engine ran on a rich mixture for the same length of time that the fast idle was "on". This resulted in excess fuel consumption.

With the introduction of the 1959 Oldsmobile, the two functions have been separated with a new and exclusive two-stage automatic choke developed by Oldsmobile engineers. An ingenious system of over-running levers allows the choke fly to open 75% sooner than previously required. The fast idle, however, remains "on" for the full warm-up period so the engine will not stall. This early elimination of the choking function represents a considerable fuel saving in cold weather when numerous short trips are made.



At Oldsmobile the Inquiring Mind is always at work, finding new and better ways to design, engineer and build finer automobiles for the most discriminating of buyers—the Oldsmobile owner. Discover the difference for yourself by visiting your local Oldsmobile Quality Dealer and taking a demonstration ride in a 1959 Oldsmobile.

OLDSMOBILE DIVISION, GENERAL MOTORS CORPORATION

OLDSMOBILE

Pioneer in Progressive Engineering ...Famous for Quality Manufacturing

engineers / scientists

investigate...

these opportunities in top-level projects in space guidance and weapons systems

ARMA is currently expanding its research, engineering and development program in the field of all-inertial guidance and weapons systems. As creator of inertial systems for the ATLAS and TITAN ICBM's, and of weapons systems for the Navy's submarine fleet, ***ARMA*** offers important positions in advanced systems research and development.

Our representative will be at the January I.A.S. Show. We invite you to visit him in our suite at Convention Headquarters for an interview in strict confidence. Or forward your resume to Mr. E. C. Lester, Professional Placement Supervisor, Dept. AE-1, address below.

We have current openings for engineers in these areas:

Project Administration	Missile Systems Evaluation
Missile Ground Equipment	Reliability & Weight Control
Computer Development	Environmental Test
Computer Programming	Systems Engineering
	Electronic Testing

6532

EQUAL JOB OPPORTUNITY For All Qualified Applicants

ARMA DIVISION

AMERICAN BOSCH ARMA CORPORATION

ROOSEVELT FIELD, GARDEN CITY, LONG ISLAND, N. Y.

Personnel Opportunities

This section is for the use of individual members of the Institute seeking new connections and eligible organizations offering employment to specialists in the aero/space industry. Any member or eligible organization may have requirements listed without charge by writing to the Secretary of the Institute.

Wanted

Structural Test and Analysis—Will be required to perform theoretical and experimental stress analyses on high-speed rotating parts, complex pressure vessels, and hydromechanical servomechanisms for jet aircraft accessory equipment. Will provide an opportunity to become familiar with programming procedures for IBM 704 and 705 electronic data processing machines. Experimental work will involve use of such tools as stresscoat, bonded wire strain gages, and photoelasticity equipment. B.S. degree in Mechanical Engineering required, and graduate work or experience in theoretical and applied mechanics desirable. Please send reply to: Engineering Employment Supervisor, Hamilton Standard Division, United Aircraft Corporation, Bradley Field Road, Windsor Locks, Conn.

Senior Aeroelasticity Engineer—Evaluate new airplane and missile designs from an aeroelastic standpoint—contribute to the aeroelastic design of production weapon systems, including considerations of vibration, flutter and static aeroelasticity. **Acoustic Specialist**—Required to predict environmental vibration and acoustical levels in and around the aircraft and to predict the response of equipment and aircraft structure to these inputs. Design of vibration isolators and acoustic insulation. You will be supported in these activities by well-trained mathematicians and engineers. **Flutter Model Designer**—Assume complete responsibility for the engineering design and testing of subsonic, transonic, and supersonic flutter models. Complete model shop test facilities available as well as supporting staff. Send replies to: R. J. Theibert, Engineering Personnel, North American Aviation, Inc., 4300 East Fifth Avenue, Columbus 16, Ohio.

Teaching Positions—Applications are being received for two permanent positions in the Department of Aeronautical Engineering at the University of Alabama. Applicants for one position should have advanced degrees. The other opening could be filled by a person holding only a Bachelor's degree if he were to show promise of becoming a successful teacher. Opportunities for consulting and research are available, both of which are encouraged. A person who has earned a Ph.D. within recent years would sense an unusually attractive opportunity to develop a graduate program and teach in his chosen field. Salaries will depend on qualifications—up to $9,000 for nine months for a professor. The usual academic tenure regulations will apply, and the University contributes toward retirement and insurance. Please address inquiries to: Colgan H. Bryan, Head, Department of Aeronautical Engineering, P. O. Box 1461, University, Alabama.

Engineers—Rotary Wing Engineers and Designers; Stress Engineers—with experience in land load; **Designers**—with experience in control system; **Dynamicists**—with experience in stability and control. Send résumé to: Leonard Goland, Director of Research and Development, Kellett Aircraft Corp., P. O. Box 35, Willow Grove, Pa.

Engineers and Scientists—Douglas Aircraft Company, Inc., designers and developers of missiles and ground support equipment, commercial and military aircraft, urgently needs large numbers of aeronautical, electrical, electronic, mechanical, chemical, metallurgical, and civil engineers; physicists and mathematicians; graduates or experienced near-graduates. There are openings in design, development, research and test, and in the fields of acoustics, hydraulics, electronics, thermodynamics, propulsion, computers, systems analysis, aerodynamics, dynamics, etc. Plants are located at Santa Monica, Long Beach, and El Segundo, Calif.; Tulsa, Okla.; and Charlotte, N.C. Missiles Field Stations are at Vandenburg AFB, Santa Maria, Calif.; Sacramento, Calif.; White Sands, N.M.; and Cocoa, Fla. Aircraft Test at Edwards AFB, Calif. Mail résumé to: C. C. LaVene, Staff Assistant to Vice-President—Engineering, Douglas Aircraft Company, Inc., 3000 Ocean Park Boulevard, Santa Monica, Calif.

Senior Vibration & Flutter Engineers—B.S. or M.S. in A.E., Applied Mechanics, Physics, with 5–10 years experience in theoretical flutter analysis of high-speed aircraft and missiles, flight flutter analysis of high speed aircraft and missiles, flight flutter testing, or vibration theory and test. To direct engineers in conducting complete vibration and flutter analyses on aircraft and/or missiles. **Senior Dynamics Engineers**—B.S. or M.S. in A.E. or Applied Mechanics with minimum of 5 years experience in aircraft or missile dynamics. To direct engineers in conducting analytical investigations of dynamic aspects of aircraft flying qualities, missile dynamics and STOL and VTOL stability control. U.S. Citizenship required. Salary in accordance with background and experience. Apply to: A. Wilder, Engineering Personnel Director, Dept. 11, Grumman Aircraft Engineering Corporation, Bethpage, L.I., N.Y.

Aerodynamicists—with theoretical and practical knowledge in supersonics and hypersonics. Salaries range from $5,000 to $30,000. There are two immediate high level positions available, in addition to several junior and intermediate openings. These lucrative positions require creative thinkers with experience in one or more of the following: aerodynamic design; stability and control; aerodynamic heating; flutter, static and dynamic aeroelasticity; performance; aerodynamic testing; flight control systems; gasdynamics, or internal aerodynamics. For immediate consideration send a detailed résumé to: E. Greenlee, Personnel Manager, Arde Engineering Division, 75 Austin Street, Newark 2, N. J.

Aeronautical Design Evaluation Engineers—Civil Aeronautics Administration needs experienced aeronautical engineers in aircraft structures and power plant installations. Aeronautical design evaluation engineers (structures) will be responsible for structural evaluation of commercial aircraft and aircraft component designs in determining compliance with Civil Air Regulations, with particular reference to helicopters and turbine powered transports. Aeronautical power plant design evaluation engineers will be responsible for the evaluation of similar aircraft with specific reference to power plant installations, including turbine engines and their related systems. Salaries range from $6,285 to $8,810 annually. Those interested should submit résumé or contact Personnel Division, Federal Building, Civil Aeronautics Administration, New York International Airport, Jamaica 30, N.Y. Telephone: OLympia 9-7000, Ext. 354.

Electronic Scientists, Metallurgists, Physicists, Technologists, and Engineers (Aeronautical, Electrical, Electronic, Industrial, General, Mechanical, and Power Plant)—The Naval Air Material Center, Philadelphia 12, Pa., has an urgent need for qualified engineering and scientific personnel to fill vacancies in the above positions. The Center is currently engaged in an extensive program of aeronautical research, development, experimentation, and test operations for the advancement of Naval aviation. Experimental work is also being conducted in the guided missile field. Starting salaries range from $4,490 to $8,330 per annum. Application for Federal Employment, Standard Form 57, should be filed with the Industrial Relations Department, Naval Air Material Center, Naval Base, Philadelphia 12, Pa. Applications may be obtained from the above address, or information as to where they are available may be obtained from any first or second class post office.

891. Teaching and Research—Available for February 1959, positions with rank of Assistant Professors, Instructors, and part-time Graduate Assistants in engineering mechanics for both teaching and research. Excellent opportunities for graduate study.

The number preceding the notice represents the Box Number of the Institute of the Aeronautical Sciences to which inquiries should be addressed.

Available

896. Contract or Project Administrator—17 years experience in aircraft and engine industries. Three years on General Manager's staff. Four years in engineering research and development contract areas. Prefer western New York or Pennsylvania, or eastern Ohio location with small, aggressive manufacturer or research group. Presently employed by a major U.S. Corporation. Age 34.

895. Engineer—Age 35. B.S. (ME) and graduate work in M.E. Employed as a General Engineer GS-12. Nature of employment: weapon system studies for past three years. Previous $4\frac{1}{2}$ years employed in evaluation of naval ordnance. Can qualify as an aeronautical, mechanical, or general engineer. Would like a career appointment to a GS-13 position in the Washington, D.C., area. A completed Form 57 will be sent on request.

893. Executive or Assistant to Executive—Age 34. B.S. in Ae.E.; M.B.A. in Industrial Management. Objective—to capitalize on past general experience in a management capacity with growth company. Experienced in administrative engineering, air force procurement, production and contract administration, reliability engineering, establish company policies and procedures, customer liaison, industrial relations, and sales. Presently employed—income $13,500. Detailed résumé and references furnished to company officers.

892. Aeronautical Engineer—Age 52. Extensive experience in aviation in industry, including 7 years as stress engineer, 5 years as chief of structural engineering section for USAF overseas which specialized in aircraft structural strength problems, such as repair, modification, aircraft damage evaluation, fire damage, corrosion, assisting in accident investigations, etc. In addition, spent several years with a large aircraft company supervising the structural strength aspects of aircraft structural repair, shop contact engineer and salvage engineer. Available immediately. Prefers position overseas but will accept position in U.S.A. either with the government or in private industry. Willing to travel. Detailed résumé forwarded on request.

890. Aeronautical Engineer—Analytical engineer with Ph.D., M.A.E., 18 years experience in aerodynamics, dynamics, structures, thermodynamics, dealing with research and development of subsonic through hypersonic and ballistic aircraft and missiles, much of it at progressively high supervisory levels. Numerous publications. Interested in position involving responsibility for these areas with established aircraft or missile manufacturer, minimum salary of $20,000. Detailed résumé furnished upon request accompanied by brief description of position under consideration.

888. Executive—Experience as Vice-President—Operations of an electronic firm. B.S. & M.S. in Aero., R.P.I. Unusual combination of abilities in technical, management, and business activities in electronics, missiles, and rocket motors. Familiar with astrophysics, and advanced space vehicle concepts; capable of forming or directing a space division; as assistant to the president or vice-president; director of advanced planning. All correspondence strictly confidential.

887. Management Assistant—Age 31. B.S. degree in Industrial Administration from Yale University. 7 years aircraft industry experience in close association with engineering and research. Registered Patent Agent, 4 years experience preparing and supervising the prosecution of patent applications. Presently responsible for the handling of all patent matters including contractural obligations. Current and historical knowledge of developments in the airframe and rotary wing fields. Previous successful sales experience and sales engineering training program in industrial products. Proved administrative ability includes the current supervision of two departments with continual high level association with management. Desires position of greater responsibility and promise. Southern California area preferred.

XUM

A word about our Advertisers

The many companies whose advertising appears in this issue are interested in you and your work. They are anxious to let you know what they are doing to help you solve research and design problems in missile, rocket, air, and spacecraft projects.

AERO/SPACE ENGINEERING's advertising pages keep you posted on new and improved materials, components, services, and supplies useful to your professional work.

To request more information on any product or service advertised, may we suggest you use the green self-addressed reply cards inserted at the end of this issue. No postage is needed. Our staff will be glad to forward all requests to the proper companies for direct reply to you.

AERO/SPACE ENGINEERING
2 E. 64th St., New York 21, N.Y.

Index to Advertisers

Aeronutronic Systems, Inc. 117
AiResearch Mfg. Divs., The Garrett Corp. 89
Allison Div., General Motors Corp. 75
American Brake Shoe Co. ..... back cover
Arma Div., American Bosch Arma Corp. 120

Bendix Aviation Corp.
★Products Div. 87
Red Bank Div. 16
Scintilla Div. 82
Boeing Airplane Co. 20
Burroughs Corp. 11

★Chain Belt Co., Shafer Bearing Div. 18
Christie Electric Corp. 73

★Eastern Industries, Inc. ..... inside front cover

Garrett Corp., The, AiResearch Mfg. Divs. 89
General Motors Corp.
Allison Div. 75
Harrison Radiator Div. 8
Oldsmobile Div. 119
General Radio Co. 113
Goodyear Tire and Rubber Co., The, Aviation Products Div. 1

Harrison Radiator Div., General Motors Corp. 8
Hexcel Products Inc. 66, 67
Huck Mfg. Co. 14

International Business Machines Corp. .. 88
International Telephone & Telegraph Corp., Industrial Products Div. 71

Janitrol Aircraft Div., Surface Combustion Corp. 114
Johns Hopkins University, The, Applied Physics Laboratory 62

Koppers Co., Inc., Sound Control Dept. 7

Lockheed Aircraft Corp., Missile Systems Div. 109

Mallory-Sharon Metals Corp 81
Martin Co., The 78, 79

Norden Div., United Aircraft Corp. 6
Nortronics, A Div. of Northrop Aircraft, Inc. 69

Oldsmobile Div., General Motors Corp. 119

Pennsylvania State University, The, Ordnance Research Laboratory 117
★Pheoll Mfg. Co., Voi-Shan Mfg. Co. Div. 14

Radio Corp. of America 77, 110
Ramo-Wooldridge Div., Thompson Ramo Wooldridge Inc. 12
Red Bank Div., Bendix Aviation Corp. . 16
Republic Aviation Corp. 111
★Rohr Aircraft Corp 90

Sargent Engineering Corp 4
Scintilla Div., Bendix Aviation Corp. .. 82
★Shafer Bearing Div., Chain Belt Co. .. 18
Space Technology Labs., Inc. 61
★Standard Pressed Steel Co., Aircraft/Missile Div. 14
Stanford Research Institute 116
Surface Combustion Corp., Janitrol Aircraft Div. 114

Taber Instrument Corp 85
Telecomputing Corp., Whittaker Controls Div. ..... inside back cover
Thompson Ramo Wooldridge Inc., Aircraft Systems Laboratory Div. 117
Ramo-Wooldridge Div. 12

United Aircraft Corp., Norden Div. 6

★Voi-Shan Mfg. Co., A Div. of Pheoll Mfg. Co. 14

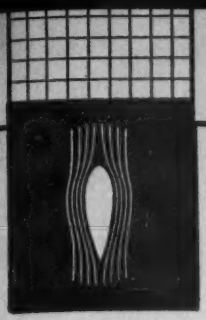
Whittaker Controls, A Div. of Telecomputing Corp. ..... inside back cover

★ Specifications and further information on the missile, rocket, and aircraft products of these companies will be found in the 1958 AERONAUTICAL ENGINEERING CATALOG

The only publication devoted exclusively to the aero/space industry, this CATALOG serves as a valuable buyers' and reference guide to sources and specifications on aircraft and missile parts and materials. It is distributed annually to Chief Engineers, Designers, Production Heads, and Purchasing Departments of all leading manufacturers of missiles, rockets, aircraft and spacecraft, and their related components; Government Agencies; Research Organizations; etc.

Published Annually by

INSTITUTE OF THE AERONAUTICAL SCIENCES
2 East 64th Street • New York 21, N.Y.



New Products and Product Literature of interest to the Profession.

▼▼▼▼

IMPORTANT NOTE: To obtain information on products listed, please use the attached postage-paid cards. Simply write in the key number assigned to each item. Key numbers are in *italics* immediately following the title; i.e. (*M1*), (*P3*), (*R12*), etc. Use a *single card* to list all items below of interest to you.

AIRCRAFT & MISSILE MATERIALS & PROCESSES

High-Strength Light Metal Castings. (*M-1*) New brochure describes castings made in controlled alloys, known as Ductaluminum 356S and 356T, offering tensile strengths as high as 42,000 psi. *American Brake Shoe Co.*, Dept. A, 530 5th Ave., New York 36, N.Y.

Fluxless "Nu-Braze" #0070. (*M-2*) A new lithium-containing silver brazing alloy used in joining structural parts intended for operating temperatures up to 900°F. *American Silver Co.*, 36-07 Prince St., Flushing 54, N.Y.

Special-Purpose Alloy Welded Tubing & Pipe. (*M-3*) New 12-page bulletin includes sizes, gages, finishes, chemical composition, and mechanical and physical properties of high-temperature, low-expansion, and high-permeability alloys. *The Carpenter Steel Co.*, Alloy Tube Div., Union, N.J.

Glass-Supported "Teflon." (*M-4*) 8-page booklet describes company's full line of standard and special grades of glass-supported "Teflon" tapes, laminates, diaphragm stock, and gasket stock. *Continental-Diamond Fibre Corp.*, Newark, Del.

"Curtisol" Filler Metal. (*M-5*) A special solder developed for titanium and titanium-base alloys; has a flow temperature between 1,300° and 1,400°F., depending on exact composition. *Curtiss-Wright Corp.*, Dept. 120, Quehanna, Pa.

Glass Fiber Insulation. (*M-6*) 8-page brochure WPD-13 covers various types of glass fiber insulations in detail; also includes section on quartz microfibers for high-temperature insulation. *L.O.F. Glass Fibers Co.*, 1810 Madison Ave., Toledo 1, Ohio.

"MST 881" 1,100°F. Titanium Alloys. (*M-7*) This new alloy exhibits strength properties excelling most steels for long periods at temperatures of 1,100°F. and for short times to 1,500°F. *Mallory-Sharon Metals Corp.*, Niles, Ohio.

Sprayed Metal & Ceramic Coatings. (*M-8*) Bulletin No. 136A covers basic characteristics, including hardness and tensile and bond strength of various coatings. *Metallising Engineering Co., Inc.*, 1101 Prospect Ave., Westbury, L.I., N.Y.

High-Shear, High-Temperature Adhesives. (*M-9*) A new family of three synthetic-rubber, phenolic-resin-base adhesives; at 600°F. their shear strength is 495 psi. *Raybestos-Manhattan, Inc.*, Bridgeport 2, Conn.

Carbon & Graphite Products. (*M-10*) 56-page manual No. 40-B gives detailed property, application, and performance data; refractory applications described include data on rocket nozzles. *Stackpole Carbon Co.*, St. Marys, Pa.

Selection & Application Guide for Small-Diameter Tubing. (*M-11*) Bulletin 41 gives characteristics and applications of 63 standard and 26 special materials cold-drawn into small tubing. *Superior Tube Co.*, 1503 Germantown Ave., Norristown, Pa.

Small-Diameter Tube Fabrications. (*M-12*) 4-page bulletin describes intricate tube forms of special contours to meet mechanical and structural requirements for aircraft and missile fuel and control parts. *United Metal Fabricators, Inc.*, 3991 Jennings Rd., Cleveland 9, Ohio.

USE THESE CONVENIENT, SELF-ADDRESSED, POSTAGE-PAID CARDS TO REQUEST ADDITIONAL INFORMATION ON ANY ITEMS, ARTICLES, OR ADVERTISEMENTS IN THIS ISSUE. ☞

Please send information on the following items mentioned on page(s) ..... in the ..... issue of Aero/Space Engineering.

NAME ..... POSITION .....

COMPANY .....

STREET .....

CITY & STATE .....

AERO/SPACE ENGINEERING

an official publication INSTITUTE OF THE AERONAUTICAL SCIENCES

(Professional Engineering Society for the Aero/Space Industry)

2 E. 64th St., New York 21, N.Y.

Request for Information

DEPARTMENT OF TECHNOLOGY LIBRARY

Please send information on the following items mentioned on page(s) ..... in the ..... issue of Aero/Space Engineering.

NAME ..... POSITION .....

COMPANY .....

STREET .....

CITY & STATE .....

AERO/SPACE ENGINEERING

an official publication INSTITUTE OF THE AERONAUTICAL SCIENCES

(Professional Engineering Society for the Aero/Space Industry)

2 E. 64th St., New York 21, N.Y.

Request for Information

DEPARTMENT OF TECHNOLOGY LIBRARY

"Vancoram" High-Purity Vanadium Metal. (*M-13*) Folder includes physical and mechanical properties and ratings of its machinability, formability, and weldability. *Vanadium Corp. of America*, 420 Lexington Ave. New York 17, N.Y.

AIRCRAFT & MISSILE PARTS & EQUIPMENT

Shutoff Valve for Seat Ejector Systems. (*P-1*) This miniature 400-cycle unit controls the flow of hot gas from an explosive cartridge to the short-time delay cycle in an ejection system; will stay open (energized) or closed against a 1,000 psi shock wave; weighs 0.34 lb. *Aero Supply Mfg. Co., Inc.*, Corry, Pa.

3 to 8 g.p.m. Constant Flow Regulator. (*P-2*) For injected water-alcohol applications; weighs 1.9 lb.; operates at temperatures from −65° to +250° F. *Aero Supply Mfg. Co., Inc.*, Corry, Pa.

"Teflon" Hose & Assemblies. (*P-3*) Catalog #103 contains 66 pages of dimensional information, engineering data, and assembly instructions on the firm's medium- and high-pressure hoses and fittings for aircraft applications. *Aeroquip Corp.*, Jackson, Mich.

Model 410 Miniature Hydraulic Servovalve. (*P-4*) First and second stages of this unit can receive and pass on particles as large as 200 microns without malfunctioning; cannot become unbalanced by oil contamination because of a single oil source for first-stage preamplifier. *Raymond Atchley, Inc.*, 2340 Sawtelle Blvd., Los Angeles 64, Calif.

BH183 "Autotemp" Temperature Indicator. (*P-5*) 4-page brochure describes cockpit indicator of exhaust gas temperature or turbine inlet temperature of jet engines. *B & H Instrument Co., Inc.*, 3479 W. Vickery Blvd., Ft. Worth 7, Tex.

Aircraft & Missile Accessories Brochure. (*P-6*) Bulletin F5910-1 describes air valves and actuators, temperature control and positioning systems, and specialized electrical test equipment. *Barber-Colman Co.*, 1400 Rock St., Rockford, Ill.

Rocket Thrust Controller. (*P-7*) A new hydromechanical unit capable of sensing and correcting small errors in thrust chamber pressure in liquid propellant rocket engines by producing a rate of change in actuator position. *Bendix Products Div.*, Bendix Aviation Corp., South Bend 20, Ind.

Miniature Pressure Switches. (*P-8*) New descriptive catalog No. CEL-602 covers company's complete line of altitude, differential, gage, and absolute pressure types. *Century Electronics & Instruments, Inc.*, 1333 N. Utica, Tulsa 10, Okla.

High-Pressure Pump & Motor Assembly. (*P-9*) Model 1213-HBG-221 is designed to drive the nose antenna in a missile; features high operational speed, permitting light-package manifold construction, and elimination of plumbing connections. *Eastern Industries, Inc.*, 100 Skiff St., Hamden, Conn.

"Finnflex" Vibration Isolating System. (*P-10*) Controls vibration by absorbing it through a network of stainless steel cable; has been tested successfully to sustain high g loadings superimposed on high vibratory loadings comparable to those of acceleration encountered during missile firing or violent aircraft maneuvering. *T. R. Finn & Co.*, 200 Central Avenue, Hawthorne, N.J.

Model 10G1515 Mass Flowmeter. (*P-11*) For missile and jet-engine fuel measurements; provides accurate mass flow rate measurement with a single meter. *Fischer & Porter Co.*, 931 Jacksonville Rd., Hatboro, Pa.

Miniature Flexible Metal Hose of Titanium. (*P-12*) Produced from 0.010 in. thick titanium strip; formed into a flexible tube of the interlocking type with an i.d. of only 0.050 in.; o.d. is 0.115 in. *Flexonics Corp.*, Maywood, Ill.

Type SR-1 All-Attitude Compass System. (*P-13*) A master flight reference system which integrates output for autopilot, doppler radar, low-altitude bombing (LAB) maneuvers, dead-reckoning equipment, and all-attitude indication. *General Electric Co.*, Schenectady 5, N.Y.

Oil-Free Gas Booster Compressor for Missiles. (*P-14*) Model 9764 requires no lubrication, ensuring a supply of uncontaminated gas for missile and test applications where gas cleanliness is of utmost importance. *Hasbd Engineering & Supply Co.*, Glendale, Calif.

Wrench-Installed "Huckbolt" Fasteners. (*P-15*) Can be installed with standard bench tools permitting use in hard-to-reach applications. *Huck Mfg. Co.*, 2480 Bellevue Ave., Detroit 7, Mich.

Antifriction Bearings. (*P-16*) New 24-page brochure AFB-2 describes all types of bearings for high-temperature and other applications. *Industrial Tectonics, Inc.*, 3602 Jackson Rd., Ann Arbor, Mich.

Miniature Servovalves. (*P-17*) These components are designed so that clogging and silting are effectively prevented through use of oversize orifices; suited to missile applications. *Kearfott Co., Inc.*, 1378 Main Ave., Clifton, N.J.

Pneumatic Vibration Isolation Systems. (*P-18*) 4-page brochure describes systems designed to protect delicate units subjected to large and rapid g load changes. *Walter Kidde & Co., Inc.*, Belleville 9, N.J.

Fluid Control Systems for Missiles. (*P-19*) Bulletin describes and illustrates valves, accessories, and control systems for the in-flight and ground-support handling of oils, fuels, oxidizers, and liquid or gaseous coolants. *Koehler Aircraft Products Co.*, 409 Leo St., Dayton 4, Ohio.

Servotransducer System. (*P-20*) Model 502400-2 is designed for continuous measurement of LOX or fuel level in missiles; by sensing differential pressure between the bottom and top of tank, normal LOX boiling will not

BUSINESS REPLY CARD
NO POSTAGE STAMP NECESSARY IF MAILED IN THE UNITED STATES
POSTAGE WILL BE PAID BY—
Institute of the Aeronautical Sciences, Inc.
2 East 64th Street
New York 21, N.Y.
FIRST CLASS
Permit No. 17809
NEW YORK, N.Y.

BUSINESS REPLY CARD
NO POSTAGE STAMP NECESSARY IF MAILED IN THE UNITED STATES
POSTAGE WILL BE PAID BY—
Institute of the Aeronautical Sciences, Inc.
2 East 64th Street
New York 21, N.Y.
FIRST CLASS
Permit No. 17809
NEW YORK, N.Y.

cause erroneous readings. *Wallace O. Leonard, Inc.*, 373 S. Fair Oaks Ave., Pasadena 1, Calif.

Liquid Oxygen & Nitrogen Converters. (*P-21*) 6-page folder contains detailed information on the performance and specifications for 5-, 10-, and 25-liter converters. *Linde Co.*, Div. of Union Carbide Corp., 30 E. 42nd St., New York 17, N.Y.

Model VO-540-A1A Helicopter Engine. (*P-22*) A 6-cylinder engine with a take-off rating of 310 hp. and maximum continuous rating of 305 hp.; weight is 435 lbs. *Lycoming Div.*, Avco Mfg. Corp., 550 Main St., Stratford, Conn.

Flow-Control Servovalves. (*P-23*) Catalog 220 describes the firm's line for use in a wide range of aircraft, missile, nuclear, and industrial applications. *Moog Valve Co., Inc.*, Proner Airport, E. Aurora, N.Y.

52-Page Facilities Brochure. (*P-24*) This comprehensive booklet details the company's history, organization, and facilities available for the design and manufacture of hydraulic, pneumatic, electronic, and mechanical components. *Sargent Engineering Corp.*, 2533 E. 56th St., Huntington Park, Calif.

"Flexhot" High-Temperature Air Duct Joints. (*P-25*) Designed for 550°F. applications; have longer cycle life with 10° self-aligning and 360° rotation. *Southwest Products Co.*, 1705 S. Mountain Ave., Monrovia, Calif.

Missile Scoring Systems. (*P-26*) New 28-page brochure illustrates many of the nation's major pilotless drones and optical scoring systems in action; shows types of cameras used in each. *Traid Corp.*, 17136 Ventura Blvd., Encino, Calif.

"Blueprint for Manufacturing in the Space Age." (*P-27*) 24-page brochure is designed to emphasize the company's capabilities for subcontracting major airframe, missile, and ground-support equipment. *Twin Coach Co.*, P.O. Box 2507, Buffalo 25, N.Y.

Quick-Release Pins. (*P-28*) New specifications brochure gives complete data on "We-Pin" pull-to-release and "BB-Pin" push-to-release pins; specially designed sealed silicone core activating mechanism prevents jamming, freezing, or accidental release. *Waldick Engineering Co.*, P.O. Box 398, Huntington St., N.Y.

ELECTRONIC & ELECTRICAL EQUIPMENT

Model PM112A3 Size 11 Stepper Motor. (*E-1*) A permanent magnet rotor bidirectional motor for precision rotary motion without reciprocating parts; for fire control, navigation, and guidance systems. *American Electronics, Inc.*, 655 W. Washington Blvd., Los Angeles 15, Calif.

Size 8 Inertia-Damped Servomotor. (*E-2*) This pill-size unit (2 oz., 1.355 in. long) is specifically designed for acceleration and deceleration damping in subminiature systems without loss in steady-state velocity. *Beckman Instruments, Inc.*, Helipot Div., Fullerton, Calif.

3/4 Amp. Diffused Junction Silicon Rectifiers. (*E-3*) These devices have peak inverse voltage ratings ranging from 50 to 600 v.; can deliver 750 mAdc of rectified current at 50°C. and 250 at 150°. *Bendix Aviation Corp.*, Red Bank Div., 201 Westwood Ave., Long Branch, N.J.

Silicon-Filament Heater Power Supply. (*E-4*) Type D-10-10-100KS4 provides two continuously adjustable d.c. power outputs, 6 to 10 v., 50 amp., and 6 to 10 v., 10 amp. *Christie Electric Corp.*, 3410 W. 67th St., Los Angeles 43, Calif.

"T," "TR," & "STR" Time Delay Relays. (*E-5*) For missile and airborne applications; feature instantaneous reset, compensation for temperature and voltage, and resistance to shock and vibration. *Curtiss-Wright Corp.*, Electronics Div., Components Dept., 260 Passaic Ave., W. Caldwell, N.J.

Low-Friction Analog-to-Digital Shaft Converter. (*E-6*) Provides direction-sensing combined with high rate of pulse output; features low friction and low inertia to prevent drag on a shaft being measured. *Data Instruments*, Div. of Telecomputing Corp., 12838 Saticoy St., N. Hollywood, Calif.

"Elinco" Synchronous Motors. (*E-7*) 28-page catalog No. El-4 contains detailed data on over 200 representative synchronous motor designs. *Electric Indicator Co. Inc.*, Camp Ave., Stamford, Conn.

TM Series Miniature Coaxial Connectors. (*E-8*) These thread-coupled units yield low VSWR at high frequencies; are designed so that electrical noise is eliminated, permitting the reception of weak, low-level signals. *General RF Fittings, Inc.*, 702 Beacon St., Boston, Mass.

"TA'POT" H5600 Slidewire-Tape Potentiometer. (*E-9*) Features direct digital readout for linear or nonlinear functions; has laboratory accuracy of 0.05 per cent. *Howell Instrument Co.*, 3101 Trinity St., Ft. Worth 7, Tex.

"Infratron" Infrared Photoconductors. (*E-10*) Technical Bulletin No. 2 presents comprehensive information and data on the present state-of-the-

USE THESE CONVENIENT, SELF-ADDRESSED, POSTAGE-PAID CARDS TO REQUEST ADDITIONAL INFORMATION ON ANY ITEMS, ARTICLES, OR ADVERTISEMENTS IN THIS ISSUE. ☞

Please send information on the following items mentioned on page(s) ..... in the ..... issue of Aero/Space Engineering.

NAME ..... POSITION .....
COMPANY .....
STREET .....
CITY & STATE .....

AERO/SPACE ENGINEERING
an official publication INSTITUTE OF THE AERONAUTICAL SCIENCES
(Professional Engineering Society for the Aero/Space Industry)
2 E. 64th St., New York 21, N.Y.

Request for Information

Please send information on the following items mentioned on page(s) ..... in the ..... issue of Aero/Space Engineering.

NAME ..... POSITION .....
COMPANY .....
STREET .....
CITY & STATE .....

AERO/SPACE ENGINEERING
an official publication INSTITUTE OF THE AERONAUTICAL SCIENCES
(Professional Engineering Society for the Aero/Space Industry)
2 E. 64th St., New York 21, N.Y.

Request for Information

art of lead sulfide infrared sensitive photoconductors. *Infrared Industries, Inc.*, P.O. Box 42, Waltham 54, Mass.

High-Altitude Pressurized Cases & Chassis. (*E-11*) For electronic equipment; can be manufactured to specifications. *Northeastern Engineering, Inc.*, P.O. Box 150, Manchester, N.H.

Model No. M-1137 D.C. Power Supply. (*E-12*) For missile launching and test applications; utilizes a magnetic amplifier power regulator and semiconductor, transistor control circuitry. *Perkin Engineering Corp.*, 345 Kansas St., El Segundo, Calif.

"MB" Miniature Contactor. (*E-13*) Capable of switching loads up to 60 amp. with control signals as small as 2.7 w. *Potter & Brumfield, Inc.*, Princeton, Ind.

DRAFTING ROOM, PRODUCTION, & MISC. EQUIPMENT

Vacuum Furnace Insulated With Metal Shields. (*S-1*) Combines high vacuum and temperatures up to 2,700°F.; for heat treating superalloys of stainless steel and refractory metals such as titanium and zirconium. *General Electric Co.*, Schenectady 5, N.Y.

"Omniscope" Optical Instrument. (*S-2*) Features a 180° hemispheric field of view; used as a periscope or borescope, it transmits this extremely wide angle field of view from inaccessible, hazardous, or remote regions. *Lerma Engineering Corp.*, P.O. 168, Northampton, Mass.

No. 74 Cleaner for Planes & Ramps. (*S-3*) Folder No. F10505 describes composition designed to clean heavily soiled airport ramp areas; also has a brightening effect on aluminum aircraft skin. *Oakite Products, Inc.*, 175 Rector St., New York 6, N.Y.

RESEARCH & TEST EQUIPMENT

Model 101-5AF Igniter Circuit Tester. (*R-1*) This more rugged version of preceding models is used primarily in field testing of solid fuel rockets. *Allegany Instrument Co., Inc.*, 1091 Wills Mountain, Cumberland, Md.

"Dynafax" High-Speed Motion-Analysis Camera. (*R-2*) Photographs at an upper rate of 25,000 16-mm. frames per sec.; completely portable; uses standard 35-mm. film. *Beckman & Whitley, Inc.*, 973 E. San Carlos Ave., San Carlos, Calif.

"Electrographic Recording Equipment." (*R-3*) 12-page brochure describes systems for high-speed translation of electronic impulses into printed, plotted, coded, or display data. *Burroughs Corp.*, Defense Sales Div., 6071 2nd Ave., Detroit 32, Mich.

Walk-In Environmental Chambers. (*R-4*) 6-page brochure describes complete missile test facilities and components testing units. *Conrad, Inc.*, Conrad Sq., Holland, Mich.

Model TT-3 Tester for Aircraft Tachometer Systems. (*R-5*) Engineering Bulletin 202 provides technical data, functional schematics, and performance specifications on this portable unit. *Consolidated Airborne Systems, Inc.*, 72 E. 2nd St., Mineola, N.Y.

PE-103 Pressure Cutoff for Wind-Tunnel Instrumentation. (*R-6*) Acts like a 30-pole, single-throw switch; connects tunnel pressures to the measuring devices, then "traps" the pressures within the measuring unit at the desired time. *Datex Corp.*, 1307 S. Myrtle Ave., Monrovia, Calif.

Hydraulic In-Flight Flutter Test System. (*R-7*) Employs high-performance electrohydraulic servosystems that control vanes which oscillate in the airstream; can deliver programed transient, as well as steady-state and swept frequency forces, to the aeroelastic structure. *ElectroSystems, Inc.*, 1035 Westminister Ave., Alhambra, Calif.

Oscillogram Scanner Model S-10. (*R-8*) Designed to solve data-reduction problems where an operator is required to scan a record over a large area; oscillogram strips up to 1,000 ft. in length may be tracked across the 66-in. illuminated scanning surface. *The Gerber Scientific Instrument Co.*, 89 Spruce St., Hartford, Conn.

Electronic Tilt Angle Transducer. (*R-9*) Aids missile launching and tracking; capable of automatically detecting and recording angular change to within 1/4 sec. of an arc. *Keuffel & Esser Co.*, Adams & 3rd Sts., Hoboken, N.J.

Model C Image Converter Camera. (*R-10*) Brochure gives details of an ultra-high-speed unit intended for the study and photographic recording of transient phenomena in the microsecond range. *Librascope Inc.*, 66 South P St., Livermore, Calif.

Vibration Testing Systems. (*R-11*) Three new bulletins Nos. 425, 435, and 470 cover vibration testing for sinusoidal and complex motion testing with force ratings from 1,200 to 2,500 lbs., 1,750 to 5,000 lbs., and 7,000 to 25,000 lbs., respectively. *MB Mfg. Co.*, A Div. of Textron Inc., P.O. Box 1825, New Haven 8, Conn.

Rotary Table for Calibrating Gyros. (*R-12*) Places the instrument under test in the same environment that would exist if the instrument were resting on a stationary platform out in space. *Pratt & Whitney Co., Inc.*, West Hartford 1, Conn.

MTG 100× Microwave Target Generator. (*R-13*) An X-band microwave radar test set capable of providing a delayed target to a pulse radar at its microwave frequency; target pulse is locked to the radar frequency by means of an AFC loop. *Remanco, Inc.*, 1630 Euclid, Santa Monica, Calif.

FIRST CLASS
Permit No. 17809
NEW YORK, N.Y.

BUSINESS REPLY CARD
NO POSTAGE STAMP NECESSARY IF MAILED IN THE UNITED STATES

POSTAGE WILL BE PAID BY—

Institute of the Aeronautical Sciences, Inc.
2 East 64th Street
New York 21, N.Y.

FIRST CLASS
Permit No. 17809
NEW YORK, N.Y.

BUSINESS REPLY CARD
NO POSTAGE STAMP NECESSARY IF MAILED IN THE UNITED STATES

POSTAGE WILL BE PAID BY—

Institute of the Aeronautical Sciences, Inc.
2 East 64th Street
New York 21, N.Y.